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Edited by

KIRTLEY F. MATHER

Permanent Secretary, Denison Scientific Association,
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EDUCATION FOR SCHOLARSHIP[1]

WILLIAM E. CASTLE

James Bryce, that observing and benevolent and wise Englishman, who spent so many years among us as his country's representative at Washington, and who knows us Americans better than we know ourselves, —Bryce has said that the finest thing in American life is our universities. Here our youth turn aside from the work-a-day world in which they grow up, and to which they will presently return, and for a few years while the mind is vigorous and keen come in daily contact with the best products of man's thinking in all the ages that have gone before. If with such contacts our young men and young women do not themselves learn to think correctly and act wisely, it will not be for lack of opportunity to learn but rather because of failure to appreciate properly and to seize effectively the opportunities offered. That our young people do, with few exceptions, value the opportunities of college life highly is shown by the practical unanimity with which in later life they send their own children to college, and when the college needs money to carry on and enlarge its work, they give money freely in its support, more freely than for any other object you can mention.

Why is it, do you suppose, that we value so highly our college days and wish our children to enjoy college days too? I can mention one reason; it is because in college days, we have opportunity to think about and to discuss general questions, aside from their immediate application to our own personal interest. This makes for clear thinking and sound judgment. We do not allow a judge to sit on a case in which he is personally interested. We think it is difficult for him to judge impartially under such circumstances. Similarly we want our young people to be

[1] An address delivered at the Ninetieth Annual Commencement Exercises of Denison University, June 15, 1921.

free from bias when they are weighing general questions and are adopting general principles which are to serve as constitutions of personal conduct for their daily lives. This is the essence of that "academic atmosphere" which surrounds a university, and which means freedom from bias, and which is sometimes condemned by men who call themselves "practical," just because it *does* mean freedom from bias and does not permit of the decision of large questions on the basis of small, local and selfish interests.

The academic atmosphere is friendly to thought, to inquiry, to the extension of every field of knowledge, without pausing to inquire whether it is immediately useful.

Benjamin Franklin, a self-educated man of genius, founded the oldest of the learned societies of America, whose official title is The American Philosophical Society held at Philadelphia for the Promotion of Useful Knowledge. Franklin, apparently, thought to rule out all knowledge that was not useful, as those do today who would admit to educational programs only vocational studies. But if Franklin or his successors ever seriously attempted to exclude from consideration in his Society any branch of knowledge on the ground that it was not useful, they long ago abandoned the attempt. The two-day program of the Annual Meeting of the Society which I sat through two years ago in the Society's little old building on historic Independence Square, with Ben. Franklin's crude apparatus in glass cases round the wall and outside the noise of a great commercial city roaring by,—that program covered every subject under the sun, from the folk lore of primitive savage tribes and the philosophy of primitive Christianity, to the best methods of preventing erosion on sea-beaches, and the ultimate constitution of atoms.

No man, however wise, can tell us what knowledge is useful and what knowledge is not or is not likely to be useful. Great industrial establishments are coming to appreciate this fact. They recognize the potential value of fundamental truth, however abstruse. For example the General Electric Company employs eminent physicists drawn away by high salaries from the laboratories of our universities, for what purpose? To plan electrical machines or to devise new uses for electricity? No, to study the

composition of the atoms of which all material objects are composed; hypothetical structures, infinitely small, which no man has ever seen. Why is the General Electric Co. interested in the pursuit of an investigation so abstruse as this? Because the man who can tell us what holds the atoms together, will place at our disposal unlimited power. If we ever learn how to utilize atomic energy, we can discontinue the mining of coal and the pumping of oil. The General Electric Co. is willing to risk a little of its surplus in the venture of trying to hasten that day.

Since it is impossible to say what knowledge is useful, the university properly takes all knowledge as its field, and seeks to increase and to diffuse that knowledge. It seeks to place on its faculty men or women who have contributed in some way to the increase of knowledge, believing that such men and women are calculated to inspire in their pupils a zeal for knowledge and a desire to increase knowledge, or else the university chooses for its faculty those who have shown an unusual aptitude for *imparting* knowledge, because the ability to acquire and to impart knowledge are not always found in the same individual, indeed such a happy combination is rather unusual. For this reason university faculties should include both types of men, teachers and investigators, but the fundamental or introductory courses should always be in charge of those "apt to teach," filled with enthusiasm for knowledge and bursting with a desire to impart it. Such only are born teachers. Unless the student, early in his course, acquires a taste for learning and desires to go on learning the rest of his life, he will never make a *scholar*, which means that he will not get the most out of college life. For after all, the *serious business of college life is scholarship*. You would never know this from reading the newspapers. You would suppose that a university was great in proportion to the strength of its athletic teams, but that is not so. The effectiveness of gun fire is measured not by the amount of noise made but by the proportion of hits. Scholarly achievements in university life are hits, athletics mostly noise.

Scholarship does not consist in the mere accumulation of facts, but in the ability to take a body of facts and draw sound conclu-

sions from them. Edison reports that the college men did not stand particularly high in the examinations which he set to test possession of a mass of miscellaneous information. By implication the colleges are to blame. But the colleges are not concerned with imparting miscellaneous information to their students. If that is what is wanted, the student would do well to stay at home and study the World Almanac. The colleges are concerned primarily in teaching young people how to think. Some one has said that it makes no difference what subject you study provided you study it in the right way, so as to master it, so as to make it your own, so that if all the books on a subject were destroyed, all the facts and statistics about it were forgotten, you could sit down and block out the *principles* on which the subject could be built anew. *That* is scholarship.

While it is true, I believe, that all branches of knowledge have educational value, it is not true that all have equal educational value, or are equally serviceable in developing all types of minds. Some studies are more useful as instruments of education at one stage of mental development or to one type of mind than to another. Experience shows that language study is one of the earliest available and most generally useful instruments of education. Students of mankind tell us that in the development of the race growth in thought and in its vehicle, language, went hand in hand, each process stimulating the other, thought being incapable of expression or even of formulation except as suitable language was found for it. What was true of the race is true in the development of the individual. Language is indispensable to thought but the amount of language study which can profitably be undertaken in individual cases varies greatly. Some find the mother tongue all they are able to master, and it is indeed adequate, if the other mental powers are well developed, to place at one's disposal in translation or otherwise the wisdom of all the ages. A boy who is dull at language, should not be kept at language study all his school days, until his interest is killed in studies of every sort, but should be allowed to go on in other fields, as he shows capacity to do so.

I speak of language study, by way of illustration merely. The principle stated will apply equally well to any other subject. All minds are not alike and so we should not have one stereotyped course of study for all. We might apply to education what Bacon said concerning food, "Now good digestion waits on appetite and health on both." The educational food must be appetizing if the student is to digest it and grow mentally by reason of it. While the tastes and aptitudes of the student should be influential in determining the choice of his studies, they should not be the exclusive consideration, any more than we should feed our children exclusively on candy just because they like it. We feed them what we think is good for them and try to present it to them in an appetizing form. That seems to be the essence of rational child feeding.

Pope's dictum that "The proper study of mankind is man" is often quoted by those who favor the humanities in educational programs: language, literature, history, philosophy, and the like; and it must be admitted that such studies have the widest appeal, since they embody an epitome of all that man has thought, said or done since he emerged from savagery, and thus involve the rudiments of civilization.

But the story of man before the beginning of the historical period is a much longer one than that which deals with the comparatively brief and modern civilized period. Yet it is a harder task to decipher that story. It has to be done in the light of archeology and anthropology, which in turn lean strongly on zoölogy and botany, and they on geology, chemistry, physics, and astronomy, and all of them on mathematics. So there is no subject which is not important to a proper understanding of man and his place in nature. The task is too great for any one mind to undertake to master them all and so scholars have to divide the field among them and each one work in his own corner. Only when the mind is young and fresh and receptive is it given to anyone to make a general survey of the whole field of knowledge, and select the small portion which with proper industry he may hope to make his own. These are the glorious days of youth, college days, when under the guidance of inspiring teach-

ers, we are permitted to go up into a high mountain and look over into the promised land of knowledge spread out before us like a map. For some of us that vision ends with college days, but the memory of it remains and makes us wish that our children may have it too, and that is why we send our sons and daughters to college.

When I was a student in college two rival theories concerning the origin and nature of man were placed before us. Part of the faculty favored one theory, part the other, so we students had to do some thinking of our own if we reached any conclusions, and to think for himself is not a bad training for the student.

According to one theory, man was not *of* the earth though he was *on* the earth. Heaven was his home, here he was a stranger, a sojourner, a wayfarer, defiled by contact with things earthly, trying to divest himself as rapidly as possible of the polluting medium in order that he might again reach a pure state. He had nothing to hope for in life except to make a safe escape from it.

According to the other theory man was a product of the earth itself, the highest stage at present in a process of orderly development. Indications of what some of the earlier stages were, through which he had passed, were seen in the lower forms of life, animal or plant, or even in the rocks, which as they decay form soil in which plants grow, on which in turn animals feed. On this theory, man was no stranger here on earth but a part of a creative process still in progress.

Some of us students adopted one theory, some the other, and I suppose today we hold much the same views that we adopted then. People do their best thinking, as a rule, when they are young, make up their minds then on fundamental questions and rarely change them afterward. But fortunately these same fundamental questions come up for study anew in every generation and are never settled. Every student for himself can apply to them the try-square of truth.

My own interest in this question of the nature and origin of man led me into the study of biology and ultimately into that of heredity, at a time when great discoveries were being made in this field. It is safe to say that since 1900 more has been

learned about heredity than had been discovered in all the preceding centuries. This subject has been studied chiefly in the case of plants and the lower animals, and much of practical value has been learned concerning it. We are now able, through a knowledge of some of the laws of heredity, to breed animals and plants better adapted to agricultural needs than any which existed before. We know how to produce any desired combination of characters in our animals and plants, provided we can first discover the characters which it is desired to combine. We know, too, that these same laws which govern heredity in plants and animals govern heredity also in man. Whatever theory we hold about the *past* of man, about his origin, we cannot fail to see that this knowledge of heredity places in the hands of the human race the possibility of controlling in a measure its own future. So far as the laws of heredity are concerned the human race could be moulded to an improved type as easily as our cultivated plants and domestic animals can be. Our knowledge of human heredity is yet too incomplete to warrant the suggestion of specific measures, except in a very tentative way, but it is time that we began thinking about the subject, and placing it before the minds of our students as a subject for investigation.

Common observation tells us that some races of mankind are better endowed physically, mentally or morally, than others. The same is true of families in a community. We have in America about every racial stock in existence poured into the melting pot, and we have a good opportunity to compare them and estimate their racial values. Shall we let them all come without restraint or shall we make a selection of the ingredients? A student of heredity who desired to improve the human stock on this continent would have no hesitation in favoring selective restriction. Even within our own borders, there occur human strains of low mentality, or loose morals, usually both, that the community would be better off without. The animal husbandman sees to it that inferior strains do not increase. Can human society do the same?

Then there are good human strains, no less than bad ones, families which generation after generation produce men of good

physique and sound minds or skilled hands. In their production the elements of environment, education and family tradition must not be disregarded, but after all due allowance is made for these factors, it is still true that heredity is an important element in producing good family strains no less than bad ones.

Can a way be found, without undue interference with personal liberty, to increase the good human strains and to decrease the poor ones?

Finally there is another problem which the human race must face in the light of biology as well as of history, that of population. There is a limit to the number of people who can live comfortably on a limited amount of land. It is true that the world supports much larger populations now than it did a few centuries ago and supports them in much greater comfort, due chiefly to advances in applied science, but still many countries are overcrowded. Overcrowding leads in time to poverty, famine, and war. Would not an intelligent control of the increase of population act as a deterrent to war and its attendant miseries? Our college graduates will not solve the problem by limiting the size of their own families. They have gone too far already in that direction and are not now replacing themselves in the population. Roosevelt pointed out very clearly the consequences of this policy, which he denounced as "race suicide." He did not wish to see our children cheated of their birthright, and this fair land won from the wilderness by the daring and toil and endurance of our fathers, abandoned by us to the swarming hordes of Europe, Asia and Africa.

At the same time it is not wise for us to adopt a policy of non-intercourse with the rest of the world. The part is not greater than the whole. Our civilization is European civilization, the world civilization of today. When that falls, ours falls. What we need is intelligent study of the whole question of population, the factors that enter into its increase, its stabilization, and its ultimate control. The question should be approached in the academic spirit, without bias, without hysteria, without fanaticism, in a spirit of fairness to all races and conditions of men.

The teachings of biology agree with the teachings of religion as regards the whole duty of man. They show that everywhere and always the interests of the race are superior to the interests of the individual. They exalt altruism and condemn selfishness. Some of us thought, when we adopted different theories about man's origin, that we had come to the parting of the ways, and that thenceforth our paths would diverge, but we have been surprised again and again to find each other working shoulder to shoulder in the same great tasks of humanity and fighting as comrades for the right and against the wrong.

We have about concluded that our differences were over definitions merely, not realities.

"In the beginning God created the heavens and the earth," are the simple, grand words of the first chapter of Genesis. These are the words of a modern poet,[2] who has spent his life in the academic atmosphere of an American college:

A fire-mist and a planet,
  A crystal and a cell,
A jelly-fish and a saurian,
  And caves where the cave-men dwell;
Then a sense of law and beauty
  And a face turned from the clod,
Some call it Evolution,
  And others call it God.

A picket frozen on duty,
  A mother starved for her brood,
Socrates drinking the hemlock,
  And Jesus on the rood;
And millions who, humble and nameless,
  The straight, hard pathway plod,
Some call it Consecration,
  And others call it God.

[2] W. H. Carruth, Each in his own tongue. G. P. Putnam's Sons, N. Y. 1908.

THE CYTOLOGY OF THE SEA-SIDE EARWIG, ANISOLABIS MARITIMA BON.

Part I

SIDNEY I. KORNHAUSER

From the Zoölogical Laboratory of Denison University, and the Biological Laboratory of the Brooklyn Institute of Arts and Sciences at Cold Spring Harbor, Long Island

WITH THREE PLATES

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1. INTRODUCTION

The forficulid, Anisolabis maritima Bon., which is found under the stones and riff-raff at the high-tide mark, is especially beautiful material for cytological study. The chromosomes are clear and distinct; the cytoplasmic structure, nicely demonstrable; and good preservation is not difficult. The differentiation of the oöcyte and nurse cell and their subsequent growth present many interesting problems which will be taken up in another paper. The origin and distribution of mitochondria in both the sex and the embryonic cells may also be studied profitably in this species. For the present, the author has confined himself chiefly to the chromosome number, and the origin and fate of the sex-chromosomes in the male. The work was begun in the summer

of 1915, suffered many delays due to the World War, but was taken up again in the spring of 1920.

I wish to express my thanks to the American Association for the Advancement of Science, which, through its Committee on Grants for Research, has enabled me to purchase microscopical lenses suitable for cytological study. These lenses have aided greatly in the completion of the paper.

2. HISTORICAL REVIEW

Two of the Forficulidae have been previously worked upon from a cytological standpoint, Forficula auricularia and the present species, Anisolabis maritima; the bulk of the work having been done upon the former species. The accounts claim a great variability in the diploid and haploid number of chromosomes, and several combinations of sex-chromosomes have been described.

The most recent and detailed contribution to the cytology of the forficulids is that of Payne ('14) on the variability of the chromosomes of Forficula. Payne states that the spermatogonial metaphases show from 24 to 27 chromosomes, twenty-four being the most usual number. The spermatocytes were found to have from 11 to 14 chromatic elements present. Zweiger ('06) states that the spermatogonial count was 24 or 26, the latter number being the more prevalent. He states that either 12 or 13 chromosomes may appear in the primary spermatocytes, and 12 to 14 in the secondary spermatocyte metaphase plates.

Stevens ('10) considered 24 the correct spermatogonial number and 12 the haploid number, one of the twelve seen in the primary spermatocytes being an unequal hetero chromosome group, which separated reductionally in the first maturation division.

Pantel ('12), whose work deals mainly with the degeneration of cells due to the presence of protozoan or insect parasites, described a variable number of chromosomes in Forficula. Spermatogonia have either 25 or 26 chromosomes; and spermatocytes, 11 to 13 chromosomes. He does not insist, however, that

this variation, which had already occupied the attention of such pioneers as Carnoy, La Valette, St. George and Sinéty, should be produced by parasitism.

Brauns ('12), in his study of the oögenesis of Forficula auricularia, believes that the haploid number in the female is 13. He quotes Professor Ludwig Will of Rostock as saying that the male diploid number of Forficula is 25, and the female diploid number 26; but that some males show 24 chromosomes in their spermatogonia. It is a striking coincidence that my counts on Anisolabis are in very close agreement with the results of Professor Will.

Randolph ('08) worked on Anisolabis and described 24 chromosomes as the diploid number in both sexes. In the primary spermatocytes she pictures a pair of almost equal hetero chromosomes which lag in the anaphase of the first maturation mitosis, but her results are not at all in accord with those described in the present paper.

3. METHODS

The material studied consisted of gonads and embryos. Nymphs were found best for the study of the germ cells. The animals were all collected at or near Cold Spring Harbor, Long Island, during June, July and August of several summers since 1915.

The best fixatives were Flemming's fluid (strong), Bouin's fluid and Benda's modification of Flemming's fluid. Various stains were employed. The Flemming material was stained in Heidenhain's haematoxylin, counterstained with Orange G or with safranin and lichtgrün. The Benda material was stained either with alizarin and crystal violet, or with methyl green and acid fuchsin of Bensley. These last two were especially valuable in the study of the xxy-complex.

Smears of testes were made in a moist chamber, immediately exposed to osmic fumes for a few seconds, and then immersed in a fixing fluid; care being taken to avoid drying. Such smears were then treated and stained like sections.

Embryos were removed from their chorionic coverings before fixation in Flemming's fluid.

The abundance of material, the large number of preparations made, and the variety of methods employed lead the author to believe that his results are fairly accurate.

All drawings were made with the aid of a camera lucida, using a 1.5 mm. Zeiss apochromatic objective and a 20 × compensating ocular. This gave an initial magnification of 3300 diameters. The drawings were reduced in the reproductions, plate XXIV about one-third and plates XXV and XXVI about two-fifths.

4. THE GONADS

Each testis consists of two long narrow tubules surrounded by a fat sheath. The length and narrowness of the tubules gives a good seriation of stages from the blind tip to the bottom where the sperm pass into the vas efferens. Near the blind or cephalic end of the tubule is a large apical cell, surrounded by young cysts of spermatogonia. These younger spermatogonial generations are larger cells and better for spermatogonial counts than those in cysts more caudad. The cysts are clearly marked off from one another by distinct walls. The spermatocytes undergo considerable growth in size and their cytoplasm acquires a large amount of mitochondria. The spermatocyte cysts occupy by far the greater part of the tubules in nymphal males. At no time during the growth period do the chromosomes disappear or lose their staining powers. The transition from ultimate spermatogonia to the formation of the spermatids must be rather slow, inasmuch as every stage in the conjugation of the chromosomes and the formation of the tetrads may be found in the testes of a single nymph, previous to the final moult. This is in marked contrast to many insects, in which the syndetic stages are very rare and difficult to find. One fortunate condition in the study of Anisolabis is the fact that each testicular tubule contains a large number of cysts and that each cyst shows slight variations in its meiotic phase.

Many testes show a central core of heterogeneous material made up of degenerating cysts. This looks much like the stream of food seen passing from the terminal chamber to the growing oöcytes of telotrophic insect ovarioles. It is not the purpose of the present paper to describe the details of the spermatogenesis or the cytology of degeneration, although the author hopes to attack these questions at another time.

The ovaries are composed of very long, and much attenuated tubules, each fastened at its narrow, cephalic end by a terminal filament reaching to the dorsal body wall. The sheath of each ovariole is composed largely of tracheal tubules, and undergoes rhythmic pulsations. The space between the egg string and this sheath is filled with a coagulable fluid. The cephalic tip of each ovariole, just caudad to the attachment of the terminal filament, is occupied by a Keimpolster; then follow oögonia, showing an occasional mitosis; while a trifle more caudad one may find pairs of oögonia both in the same mitotic phase. About one-tenth of a millimeter from the Keimpolster occur the ultimate oögonial mitoses. Here four cells all in the same stage of mitosis may be found, and each cell gives rise to an oöcyte and a nurse cell which continue in close connection and accompany each other from this time until the end of the growth period. Syndesis occurs immediately after the differential mitosis, the oöcyte here outstripping its sister nurse cell in size. Soon, however, the nurse grows much larger than the oöcyte, and, at about six-tenths of a millimeter from the Keimpolster, they orient in single file (oöcyte, caudad; nurse cell, cephalad), acquire follicular walls, and proceed in the accumulation of yolk material. The large nurse cell with irregular nucleus is surpassed finally in size by the oöcyte, and becomes a small cap on the cephalic end of the ovum.

5. THE DIPLOID CHROMOSOMES

A. The female

Oögonia in their ultimate mitoses show 26 clear, distinct chromosomes, well separated from one another. Numerous drawings were made and the number 26 established without doubt. Fig-

ures 1–4 (Plate XXIV) represent four typical metaphase plates. Subsequent observations lead the author to believe that, of the twenty-six chromosomes, twenty-two are autosomes, and four are two double x-chromosomes, which appear in quiescent oögonial nuclei as two double and almost square karyosomes.

The female somatic number has likewise been established to be 26. The counts were made on well-developed embryos, treated by the same methods as the gonads. Numerous mitoses in the hypodermal cells and in the developing central nervous system offered abundant material for statisfactory counts. A suitable embryo would be selected and then sketches made of every distinct metaphase plate in the whole series of sections. Figures 5–8 (Plate XXIV) represent four groups showing 26 chromosomes each. These are selected from a single embryo in which dozens of clear counts of 26 were made. In the somatic cells, as has been noted by previous investigators, there is a much greater variation in the size of the cells and the form of the chromosomes (whether long and narrow, or short and broad) than there is in the germ cells. The chromosome number, however, remains constant, with the occasional exception of a giant cell with twice the diploid number present.

B. The male

Spermatogonia likewise have clear, clean-cut chromosomes, twenty-five in number, cells near the apex of the tubule serving best for such counts. These spermatogonia have a large amount of cytoplasm and the chromosomes are well separated (Plate XXIV, figs. 9–12). In the cytoplasm onemay often encounter bodies, which might be mistaken for chromosomes in deeply stained haematoxylin preparations, especially after Bouin or sublimate fixation. In such preparations these cytoplasmic masses are quite as dark in color as the chromosomes and not greatly different in size from the average Anisolabis chromosome. These bodies are shown, light gray in tone, in figures 9, 11, and 12 of Plate XXIV. After Benda fixation these cytoplasmic bodies take mitochondrial stains, and stand out in marked contrast to the

chromosomes, being purple in crystal violet + alizarin, and red in methyl green + acid fuchsin. The use of these stains enables one to establish the number twenty-five for the spermatogonial chromosomes. As will be shown later, twenty-two of these are autosomes, two form an x-complex, and one is a y-chromosome.

The male somatic number was likewise established by the study of serial sections of embryos in which many counts of single individuals were made. Figures 13 to 16 (Plate XXIV) are typical 25 chromosome plates of such male embryos. The following important variation, the only characteristic one so far found in the study of Anisolabis, must be noted. In male embryos, with typical 25 chromosome cells, one finds clear metaphase plates with only 24 chromosomes. This happened too often to be purely accidental or due to error or oversight. A probable explanation of the phenomenon will be given in Part 8.

6. THE SPERMATOCYTE CHROMOSOMES

The initial and most fundamental facts to be established were that twelve chromatic elements were uniformly present in primary spermatocyte metaphase plates (Plate XXV, figs. 28–29), and that half the secondary spermatocytes possessed twelve chromosomes and the other half had thirteen (Plate XXVI, figs. 44–47). These facts made necessary the careful study of the origin of the twelve primary spermatocyte chromosomes.

From the 25 spermatogonial chromosomes are formed eleven autosomal tetrads and a heterochromosomal hexad, which I have called the xxy-complex and which may be seen in figures 17–27 (Plate XXV). The autosomal threads and tetrad formation are omitted from these figures. The evidence is rather clear that the tetrads are formed by parasyndesis, and it is hoped that additional smear preparations will enable the author to deal with this point in more detail in another paper. Figures 17–22 show merely the nuclear outline and the xxy-complex, stained in iron-haematoxylin, the relative intensity of the stain being depicted as accurately as possible in the figures.

Figure 17 is an early leptotene stage, the autosomal threads just emerging from the telophase chromosomes of the ultimate

spermatogonial division. Here there is seen a double, rather angular body (xx), and a deeply staining sphere (y). With the establishment of the leptotene threads (Plate XXV, fig. 18), the xx-and the y-element come into close apposition and remain connected, sometimes merely by a small strand (Plate XXV, figs. 19, 20), and also during syndesis they continue this connection. When the zygotene threads are well formed, the xx-element separates from the y-element. Often they come to lie at some distance from each other in the nucleus, but apparently not under control of the centrosome at the positive pole of the nucleus (Plate XXV, figs. 21, 22).

With the beginning of the strepsinema the xx-element and the y-element again approach each other and are again connected by a narrow strand (Plate XXV, figs. 23, 24). The xx-element reveals its two-fold constitution, when viewed at a favorable angle in well-decolorized haematoxylin preparations, and especially well in crystal violet + alizarin slides. At the establishment of the strepsistene stage we notice the coalescence of the xx-and the y-element. In iron-haematoxylin the y-element has a lighter cortical zone, and a more deeply stained center. The doubleness of the x-portion is no longer so distinct (Plate XXV, figs. 25–26).

When the autosomal tetrads are formed, but are still very granular, there appears on the xxy-complex a highly refractive spherule (fig. 27, *nl*), which separates from its parent mass at about the time the smooth, deeply staining tetrads are established. This nucleolar body may then lie anywhere in the nucleus, even in close appostion to one of the autosomal tetrads. As the centrosome divides and preparation is made for the first maturation spindle, this nucleolar body diminishes in size and finally disappears, leaving eleven autosomal tetrads and the xxy-hexad to enter the metaphase plate.

Not only form but also differential reaction to stains enables one to trace the evolution of the hexad. In safranin + lichtgrün, the y-element is not so deep a red as the xx-component, in stages corresponding to those shown in figures 17–26. The y-element also appears vacuolated, and has a greenish tinge in the early

strepsinema. Finally in the later strepsistene stage, when the chromatic spherule is given off, the y-element stains as deeply as the two x-elements. In crystal violet + alizarin the y-element is purple, and the xx-element brown with small purple granules in it; whereas the nucleolar sphere of the late strepsinema is deep purple. In methyl green + acid fuchsin, the y-element is red, and the xx-element green. As the two fuse, in stages corresponding to figures 25 and 26, the y-element gradually loses its red color and becomes green, while the extruded nucleolar spherule is a deep red. We must, I believe, assume that the extrusion of this nucleolar spherule is in a vital way connected with the change in "stainability" of the y-element.

The twelve chromosomes of the primary spermatocyte metaphase (Plate XXV, figs. 28, 29) are so widely separated that, in lateral views with very high magnification, one may focus sharply on each element in the spindle. Good lateral views of the xxy-hexad may be obtained not only in metaphase plates (figs. 30–33) but also in anaphase stages (Plate XXVI, figs. 37, 38). Figure 34 (Plate XXV) shows the twelve elements of the metaphase plate viewed laterally, the chromosomes of the several foci being here transposed into a single row from the camera lucida drawing. The hexad is on the extreme right. Figure 35 represents a corresponding stage, but taken from a smear slide. The contents of the cell were so spread out that a single focus displayed all the chromosomes with no overlapping. In the smear slides the chromatic elements appear smaller but retain all the features seen in sections, and offer a very good check upon the latter.

The attachment of the y-element and the xx-element seems to be either terminal $\left\{\begin{matrix} y \\ x \\ x \end{matrix}\right\}$ or lateral $\left\{\begin{matrix} y \\ xx \end{matrix}\right\}$. Various arrangements of the elements taken from metaphases and anaphases are seen in figures 30–38. Figure 36 (Plate XXV) shows seven separate xxy-hexads, the y-element in all cases being uppermost in the figures.

In the first meiotic division (Plate XXVI, figs. 37–41) the y-chromosome passes to one pole and the double x-chromosome

to the other. Figures 40 and 41 represent two anaphase plates of a single cell, similar to that shown in figure 39, but cut through the equatorial zone so that one section contains one plate and the next section its sister. In both plates eleven of the chromosomes, the autosomes, are similar; and the large xx-element in figure 41 and the smaller y-element in figure 40 occupy corresponding positions.

Following the telophase of the first meiotic division there is a definite interkinetic period with the establishment of a well-defined, nuclear membrane (Plate XXVI, fig. 42). The centrosomeof the primary spermatocyte telophase remains visible and establishes the spindle of the secondary spermatocytes. The dyads remain rather distinct, deeply staining, block-like masses in the nucleus of the interkinetic stage.

With the formation of the secondary spermatocyte spindles we now have two distinct types of metaphase plates: those with twelve chromosomes, and those with thirteen (Plate XXVI, figs. 43–47). The twelve chromosome plates consist of 11 dyads and a y-chromosome. The thirteen chromosome plates consist of 11 dyads and two x-chromosomes, which separated from each other during the interkinetic period and are here represented by two discrete elements. Figures 46 and 47 (Plate XXVI) show two pairs of sister second spermatocytes, one in each pair containing twelve, and the other thirteen chromosomes. The former figure is taken from a section, the latter from a smear slide.

Occasionally giant secondary spermatocytes are formed with all the chromatic elements of the first maturation spindle present, the chromosomes having divided but the cytoplasm having failed to do so. Two such metaphase plates are shown in figures 48 and 49 (Plate XXVI) and each has 25, well-defined chromosomes.

The second maturation mitosis divides all the chromosomes equationally, and they pass to their respective poles without lagging. Figures 50 and 51 represent sister anaphase plates, drawn from a smear slide, and showing an exact correspondence in their chromatic elements. The spermatids (fig. 52) are formed

immediately after the telophase of the second meitotic division and bear a remarkable resemblance to the interkinetic spermatocytes, except that they are smaller and that their chromosomes soon break up into granules.

7. DISCUSSION

The author believes the female diploid number of chromosomes of Anisolabis to be twenty-six in both germ cells and soma cells, as against twenty-four claimed by Randolph ('08) for both sexes. The normal male diploid number is twenty-five although somatic mitoses with twenty-four chromosomes are found.

The union of the two x-chromosomes into a single body is probably the explanation of this last phenomenon, and this supposition is strengthened by the fact that, in the growth of the spermatocytes and in the first spermatocyte division, these two x-elements of the xxy-hexad are in close apposition, leading to the assumption that the two parts are intimately related. The x-complex may be considered either as having originated from a single x-chromosome or as now being in the process of the formation of a single x-chromosome out of two previously distinct chromatic elements.

Another view of the 24 chromosome somatic male cells is possible: namely, that after a number of somatic divisions, the y-element undergoes a dissolution. From the behavior of the y-element in the growth of the spermatocytes, one may infer that it is greatly different from the normal chromosomes; for, not until the late strepsistene does it acquire a true chromatic stain, when tested with alizarin + crystal violet or with methyl green + acid fuchsin. Only after giving off the nucleolar spherule, which takes the mitochondrial stains deeply, does its definite chromatic nature appear.

Our interest in the y-chromosome must be again kindled in view of the recent type of inheritance described by Castle ('21) linked with this exclusively paternal chromatic element. We must try to determine whether the y-chromosome is a chromosome in a state of formation or whether it is merely a degenerate x-chromosome.

In regard to the sex-chromosome of the forficulids, the author would maintain that in Anisolabis we have neither unpaired accessory chromosomes, nor a pair of unequal heterochromosomes, nor a pair of almost equal heterochromosomes, as previously described by various authors. The following conditions are believed to exist: the female diploid number is 26, consisting of 22 autosomes and 4 x-chromosomes; the female haploid number (inferred) is 13, consisting of 11 autosomes and 2 x-chromosomes; the male diploid number is 25, consisting of 22 autosomes, 2 x-chromosomes, and a y-chromosome; half the second spermatocytes show 13 chromosomes, and the other half 12. The former gives rise to two female determining spermatozoa, containing 11 autosomes and 2 x-chromosomes; the latter gives rise to two male determining spermatozoa, with 11 autosomes and a y-chromosome.

It will be an interesting problem to see if the small mature males, occasionally found in Anisolabis, are in some way related to an upset in the normal chromosomal distribution described above.

8. SUMMARY

1. The diploid number of chromosomes in Anisolabis is 26 in the female, and 25 in the male both in somatic and germinal cells.

2. The only variation from the above is in the male somatic cells, where only 24 chromatic elements may often be counted. This may be due to a fusion of the two x-chromosomes in the male cells or to the loss of the y-chromosome.

3. Primary spermatocytes show twelve chromosomes: eleven are autosomal tetrads, and one an xxy-hexad.

4. The xx-element together with 11 autosomal dyads pass into one secondary spermatocyte; the y-element and 11 autosomal dyads pass into the sister cell.

5. In the interkinetic period the two x-chromosomes separate and appear as discrete bodies in the second maturation spindle. We therefore find 13 chromosomes in one half the metaphase plates, and 12 chromosomes in the other half.

6. All chromosomes divide equationally in the second spermatocyte division, giving rise to female determining spermatozoa with 11 autosomes and two x-chromosomes, and male determining spermatozoa with 11 autosomes and a y-chromosome.

7. The y-chromosome of the spermatocyte is chemically and morphologically rather unlike the x-chromosomes during the growth period up until the late strepsinema, when it gives off a nucleolar spherule which takes mitochondrial stains.

Granville, Ohio, June 28, 1921.

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10. EXPLANATION OF PLATES

All drawings were made with the aid of a camera lucida. A 1.5 mm. Zeiss apochromatic objective and a 20× compensating ocular was the optical combination used. All figures were drawn at 3300 diameters magnification and subsequently reduced, in Plate XXIV the reduction being about one-third and in Plates XXV and XXVI the reduction being about two-fifths.

Plate XXIV

Figs. 1–4. Oögonia, metaphase plates, polar view, 26 chromosomes.

Figs. 5–8. Somatic mataphase plates, polar view from female embryo, 26 chromosomes.

Figs. 9–12. Spermatogonia, metaphase plates, polar view, 25 chromosomes.

Figs. 13–16. Somatic metaphase plates, polar view from male embryo, showing 25 chromosomes.

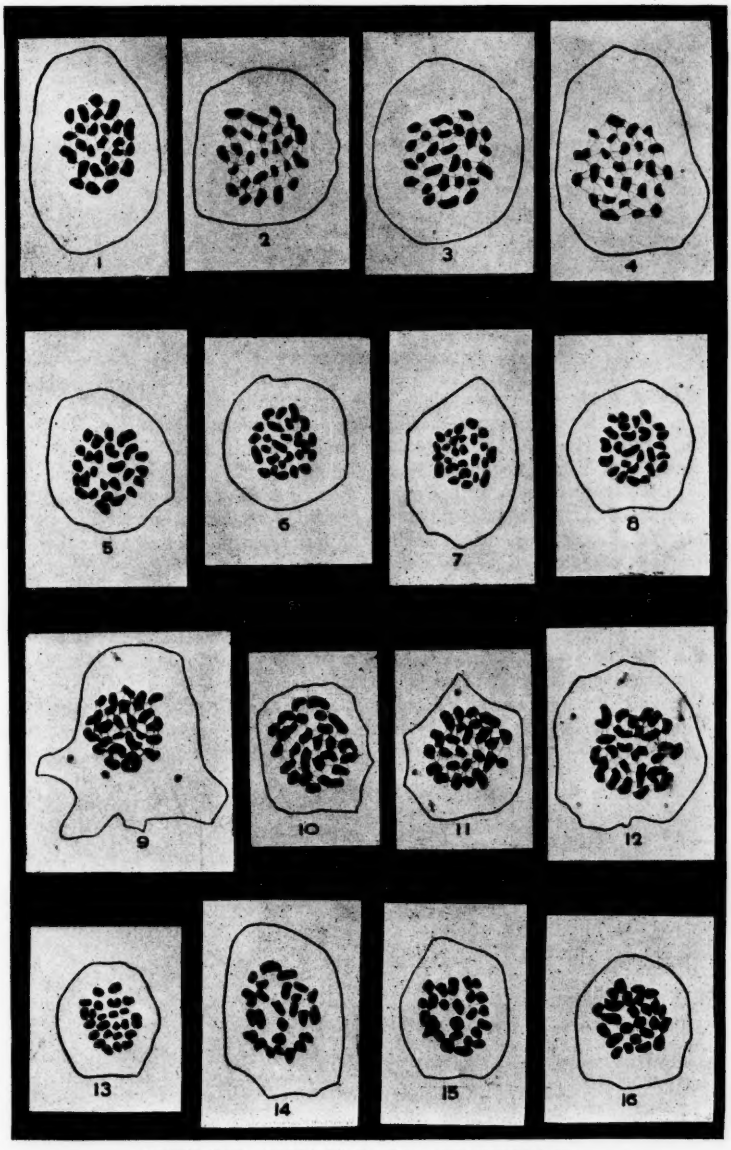

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Plate XXV

Primary Spermatocytes

Fig. 17. Early leptotene nucleus, showing xx and y

Fig. 18. Trifle later stage than Fig. 17, xx and y in close apposition.

Figs. 19–20. Nuclei of syndetic cells, xx and y connected.

Figs. 21–22. Diplotene nuclei, showing separation of xx and y-elements.

Figs. 23–24. Early strepsistene nuclei, showing reunion of xx and y.

Figs. 25–26. Later strepsistene nuclei, showing fusion of xx and y.

Fig. 27. Late strepsistene, showing the formation of the nucleolar spherule (nl)

Figs. 28–29. Primary spermatocytes, metaphase plates, polar view, showing 12 chromosomes.

Figs. 30–33. Primary speratocytes metaphase, lateral view, showing xxy-hexad

Fig. 34. The twelve chromosomes of a primary spermatocyte metaphase. xxy on extreme right, taken from a section.

Fig. 35. Same stage as figure 34, except that it was taken from a smear slide.

Fig. 36. Various forms of the xxy-hexad, as seen in metaphases and anaphases of primary spermatocytes viewed laterally. y-element shown above in each case.

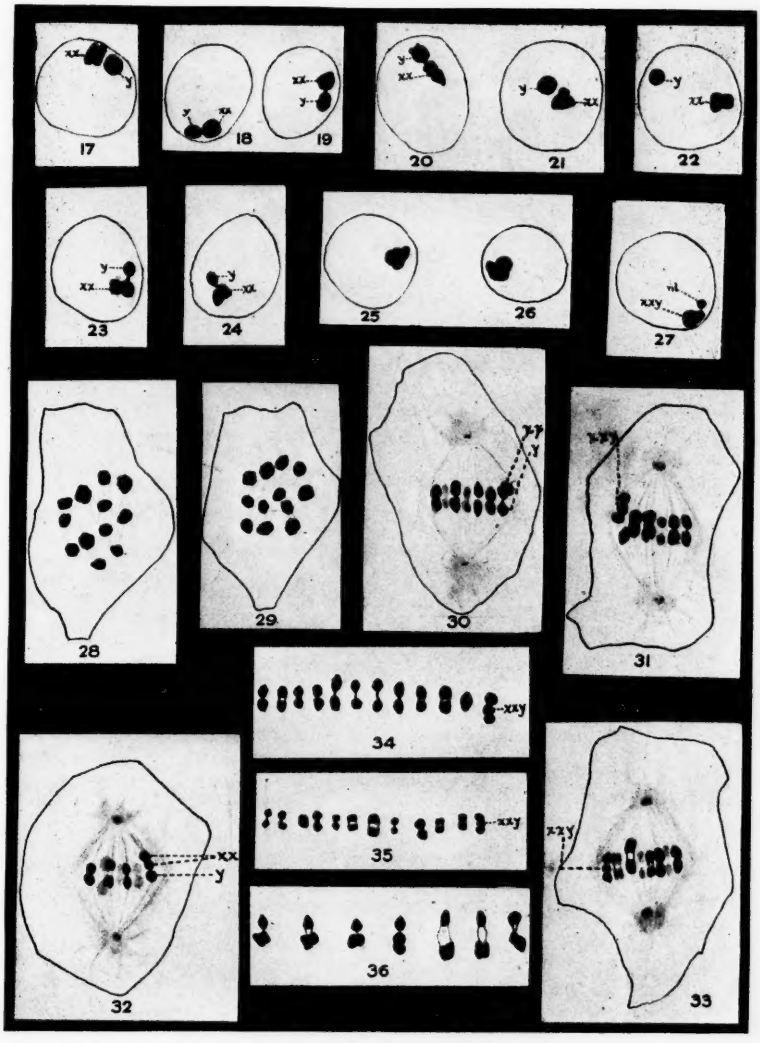

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Plate XXVI

Figs. 37–38. Anaphases of primary spermatocytes, showing separation of xx and y. In figure 37, the hexad is in linear arrangement; in figure 38, the two x-chromosomes are placed side by side and the y-chromosoms is above.

Fig. 39. Late Anaphase of primary spermatocyte, the xx-element passing to the upper pole in the figure.

Figs. 40–41. Sister anaphase plates of cell corresponding to figure 39. In figure 40, the y-element is included; in figure 41, we see the xx-element.

Fig. 42. Interkinesis.

Fig. 43. Metaphase secondary spermatocyte, lateral view.

Fig. 44. Metaphase secondary spermatocyte, polar view, showing 13 chromosomes.

Fig. 45. Metaphase secondary spermatocyte, polar view showing 12 chromosomes.

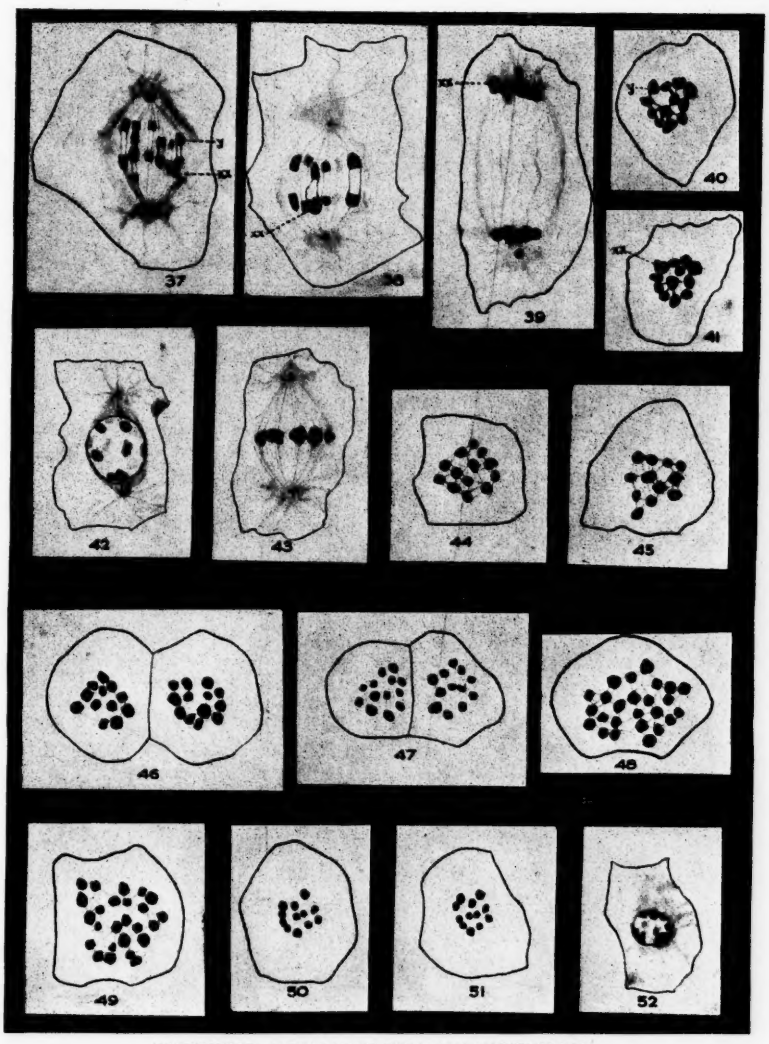
Fig. 46. Sister cells, secondary spermatocytes, metaphase, polar view: one showing 12, the other 13 chromosomes.

Fig. 47. Same stage as figure 46, but taken from a smear slide.

Figs. 48–49. Giant secondary spermatocytes, metaphase, polar view, showing 25 chromosomes

Figs. 50–51. Sister anaphase plates of a secondary spermatocyte (12 chromosome type), showing exact distribution of chromatin to spermatids.

Fig. 52. Spermatid, shortly after second meiotic division.



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NOTES ON ARCTIC ORDOVICIAN AND SILURIAN CEPHALOPODS

Chiefly from Boothia Felix—King William Land, Bache Peninsula, and Bear Island

AUG. F. FOERSTE

To Dr. Olaf Holtedahl we owe a number of very valuable papers bearing directly on American Arctic geology. In 1912 he published his paper "On Some Ordovician Fossils from Boothia Felix and King William Land collected during the Norwegian Expedition of the Gjøa, Captain Amundsen, through the Northwest Passage" in the Videnskapsselskapets Skrifter, I, Mat-naturv. Klasse, 1912, No. 9. The fossil material of this expedition was collected by Lieutenant Godfred Hansen, the second in command. The fossils forming the subject of Dr. Holtedahl's paper were collected at two localities. One of these was at Cape Christian Frederick on the west coast of Boothia Felix, Longitude 94° west and Latitude 69° 30′ north, where collecting was done in September 1903. The other was somewhere on King William Land. It is known that in 1903 Hansen collected fossils on the Pfeffer River on King William Land, about 20 miles west of Gjøa Harbor, where the expedition had wintered. This harbor is on the south coast of King William Land at Longitude 96° west. Unfortunately, on account of inadequate labelling, it is impossible now to determine from which of the two localities the various specimens under consideration were obtained. The fossils were identified by Dr. Holtedahl as *Receptaculites oweni* Hall, *Halysites* sp., *Columnaria* sp., with partly separated corallites, *Maclurites* sp., *Eurystomites* sp., *Actinoceras beloitense* (Whitfield), *Actinoceras* sp. (cf. *tenuifilum* Hall), and *Gonioceras occidentale* Hall (Holtedahl, Plate III. fig. 1). This is a Black River fauna. Judging from the promi-

nence of the oblique lateral ribs toward the ventro-lateral angles in the figure of the *Eurystomites* published by Dr. Holtedahl (Holtedahl, Plate II, fig. 1), this Nautiloid is a *Plectoceras* related to such Black River forms as *Plectoceras undatum* (Conrad) and *Plectoceras halli* (Foord). The siphuncle of the specimen identified as *Actinoceras beloitense* (Whitfield) (Holtedahl, Plate IV, fig. 2) appears to be too small for typical forms of that species. The form figured as *Actinoceras* sp. cf. *tenuifilum*(Hall) (Holtedahl, Plate III, fig. 2) was kindly loaned to the present writer by Dr. Holtedahl, and is figured on Plate XXVI of the present paper. It has shorter camerae and a smaller siphuncle than *Actinoceras tenuifilum*, and probably belongs to a new species of which more material is needed to discriminate it satisfactorily from other forms.

In the specimen figured by Holtedahl as *Endoceras* (*Cyclendoceras*) *annulatum* Hall (Holtedahl, Plate IV, fig. 1), the annulations are much stronger and the number of camerae in a length equal to the diameter of the conch is much less than in typical forms of that species. Moreover, it does not present the strong downward flexure of the annulations on the ventral side of the conch characteristic of typical *Cyclendoceras*. Its general appearance is more like that of a *Dawsonoceras*, but, in the absence of any knowledge of its siphuncle, it is impossible to state positively that it could not be a *Cyclendoceras*.

In addition Dr. Holtedahl loaned also a number of Actinoceroids, a part of which are here figured and described in the hope that further material may be collected elucidating these forms. One of these is named *Actinoceras amundseni* in honor of Captain Roald Amundsen, the leader of the expedition. The material forwarded includes also a peculiar orthocone, flattened on one side, for which the new term *Leurorthoceras hanseni* is proposed in honor of Lieutenant Godfred Hansen, the geologist of the expedition and the second in command. It is regarded as a new genus. The Actinoceroids and the species of *Leurorthoceras* just mentioned are regarded as of Black River age.

In 1913 the same Videnskabs-selskabet of Kristiania published Dr. Holtedahl's paper on "The Cambro-Ordovician Beds of

Bache Peninsula and the Neighboring Regions of Ellesmere Land" in No. 28 of the Report on the Second Norwegian Arctic Expedition in the "Fram" 1898–1902. This expedition was led by Captain Otto Sverdrup; Per Schei was the geologist of the expedition. Bache Peninsula lies between 79° and 79°16′ north latitude on the eastern coast of Ellesmereland and extends as far eastward as 74° 30′ west longitude. Cape Camperdown forms its southeastern corner and Victoria Head its northeastern corner. The lowest strata on the peninsula are exposed at Cape Camperdown. From this locality Dr. Holtedahl figured a cranidium, a free cheek, and a pygidium under the term *Ptychoparia* sp. The strata at Cape Camperdown dip north-northwest and are overlaid stratigraphically by those at Victoria Head.

From the *Orthoceras* limestone, "a bed of light greyish-white limestone, about 350 ft. thick which cropped out midway up the vertical face of Cape Victoria Head," Dr. Holtedahl figured a cranidium of another *Ptychoparia* and a cranidium of *Illaenurus*. In addition, sections of fossil fragments, especially of *Orthoceratidae*, are fairly common. Of these *Orthoceratidae* Dr. Holtedahl kindly loaned me a number of specimens. At first sight these appeared to be very unpromising material, consisting chiefly of fragments of conchs exposing oblique cross-sections of their interiors. In most cases not even enough of the conch is present even for generic determination. However, in several cases, by grinding away the matrix, enough of single conchs was revealed to admit of fairly detailed study. Two of these specimens are figured and described here under the terms *Clarkoceras holtedahli* and *Ellesmeroceras scheii;* the first is named in honor of Dr. Holtedahl, to whose paleontological studies we are indebted greatly in our knowledge of Arctic faunas, and the second is named in honor of Per Schei whose zeal in collecting made some of these paleontological studies posssible and whose untimely death we mourn. The second species belongs to the *Endoceratidae*, but is regarded as differing sufficiently from typical *Endoceras* to warrant a distinct generic name. It has its nearest relatives among *Endoceratidae* of Canadian age.

Clarkoceras holtedahli is closely related to the genotype *Clarkoceras newtonwinchelli* (Clarke) from the Shakopee member of the Canadian in Minnesota. A third specimen, here figured but not described (Plate XXVII, figs. 4, *A*, *B*, *C*), possibly may be an Endoceratitic shell with a large siphuncle in contact with the ventral wall of the conch, as in *Cameroceras tenuiseptum* (Hall), but, in the absence of any definite knowledge of the siphuncle in this Bache Peninsula specimen, its generic reference remains impossible.

Dr. Holtedahl was inclined to regard the *Orthoceras* limestone specimens figured by him as Cambrian. There is a possibility of their being Ozarkian instead. *Illaenurus convexus* Whitfield occurs in the Mendota member of the Ozarkian in Wisconsin and several *Ptychopariae* occur in the Ozarkian of Point Levis, in Quebec, and in the Potsdam of New York and in the Kittatinny of New Jersey, of which the latter also are regarded as Ozarkian by Ulrich. Possibly both Ozarkian and Canadian horizons are represented in the *Orthoceras* limestone of Bache Peninsula, since the cephalopods here described have a distinctly Canadian appearance.

Above the *Orthoceras* limestone on Victoria Head is first a series of sandstones alternating with limestones, and next a "bed of close-grained brown limestone, about 100 feet thick, some of the layers of which are fossiliferous." From this brown limestone Dr. Holtedahl figures a *Hormotoma*, a *Maclurea*, and a *Bathyuriscus*. The genus *Hormotoma* is represented by numerous species in the Canadian. *Maclurea* also is represented by a number of species in the Canadian of Newfoundland, Vermont, and New York. If the pygidium figured from the brown limestone could be referred to *Bathyurus* or *Bathyurellus* instead of *Bathyuriscus* then again it would find numerous relatives in the Canadian. It seems possible, therefore, to regard the brown limestone in the upper part of the Victoria Head section as of Canadian or even of post-Canadian age.

From Victoria Head, in his work on "Palaeontology of the Coasts of the Arctic Lands" (Quarterly Journal of the Geol. Soc. of London, Vol. 34, 1878), Etheridge reports the discovery of *Maclurea magna* Leseur, a typical Chazyan fossil.

From Norman Lockyer Island, about 8 miles directly north of Victoria Head, Dr. Holtedahl lists *Halysites gracilis* (Hall), *Calapoecia canadensis* Billings, *Streptelasma corniculum* Hall, *Mesotrypa* cf. *discoidea orientalis* Bassler, *Hallopora angularis* (Ulrich), *Rafinesquina deltoidea* (Conrad), *Plectambonites sericeus* (Sowerby), *Orthis tricenaria* Conrad, *Triplecia* sp., *Rhynchotrema inaequivalvis* (Castelnau), *Trochonema umbilicatum* (Hall), *Gonioceras occidentale* Hall, *Thaleops ovatus* Conrad, *Nileus* (*Bumastus*?) sp., and *Leperditia fabulites* (Conrad). This is a characteristic Black River fauna, and is known to be wide spread in Arctic areas.

The paleontological results of the voyage of the "Fram" in the southwestern part of Ellesmereland were described by Dr. Holtedahl in his paper "On the Fossil Faunas from Per Schei's Series B in Southwestern Ellesmereland," which forms No. 32 of the series of Reports on the Second Norwegian Arctic Expedition in the "Fram" in 1898–1902, published by the Videnskabs-Selskabet of Kristiania, in 1914. By far the greater part of this report is concerned with the Helderbergian fauna of Southwestern Ellesmereland, equivalent to the Keyser of Maryland; however, lower faunas also are mentioned. Three Niagaran species, *Strophonella* cf. *euglypha* (Hisinger), *Conchidium arcticum* Holtedahl, and *Ceraurus* sp., are described from Baadkap, 30 miles southwest of the southwestern corner of Ellesmereland, on the northern shore of North Devon. Three species, probably of Black River age, are listed from South Cape, on the west side of the mouth of Harbour (Havne) Fjord, on the south shore of Ellesmereland, at 84° 30′ west longitude; these species are *Halysites* cf. *gracilis* (Hall), *Strophomena* sp., and *Maclurites* sp. This Black River horizon is underlaid by 1300 to 1600 feet of strata consisting of limestone conglomerates with marly shales and pure limestones which possibly correspond to the Canadian and Ozarkian strata of the Bache Peninsula.

Dr. Holtedahl's "Notes on the Ordovician Fossils from Bear Island collected during the Swedish Expeditions of 1898 and 1899," published in 1918, form No. 1 of volume V of the Norsk Geologisk Tidsskrift. Bear Island is a small isolated island

about two thirds of the distance from Norway to Spitzbergen. Here A. G. Nathorst collected in 1898 the bulk of the fossils studied by Holtedahl. This was supplemented by material collected in 1899 by J. G. Anderson, which, however, did not contain much that was new. Both collections are deposited in the Riksmuseet, at Stockholm, Sweden. These collections consist of Black River fossils occurring in the upper part of the Heclahook system in a series of strata known locally as the Tetradium limestone. From this Tetradium limestone the following species were listed: *Tetradium* cf. *syringoporoides* Ulrich, Bryozoa several species, Crinoid stems, *Rafinesquina* sp., *Orthoceras* (*Kionoceras*) sp. (Holtedahl, Plates XI, fig. 2), *Endoceras* (*Vaginoceras*) sp. (Holtedahl, Plates X, fig. 1), *Endoceras* (*Cyclendoceras*) sp. (Holtedahl, Plate IX, fig. 5), and *Gonioceras* (*occidentale* Hall?) sp. (Holtedahl Plate XI, fig. 3); also various Actinoceroids (Holtedahl, Plate X, figs. 2, 3, and Plate XI, fig. 1).

Regarding these species Dr. Holtedahl emphasizes the fact that *Tetradium* and *Gonioceras* are typical American genera, well represented in North America, while in Europe *Tetradium* is listed only from the Borkholm in the Baltic area and *Gonioceras* apparently does not occur at all. In Asia, moreover, *Gonioceras* is known only at a single locality, in West Shantung in North China, where it occurs associated with *Actinoceras* aff. *tenuifilum* Hall, another typical American Black River species. Regarding *Actinoceras*, Dr. Holtedahl states that this genus may be said to be characteristic of the American faunal province in Ordovician times, while in Silurian times it has spread also to Europe and is found quite commonly in England and in the Scandinavian-Baltic regions. A true *Actinoceras*, somewhat resembling the Silurian *Actinoceras imbricatum* Hisinger, is quite common in the uppermost Ordovician of some districts at the western side of the Kristiania region, in Hadeland and Ringerike. This Norwegian occurrence possibly may indicate that the *Actinoceras* stock came from the west or northwest in upper Ordovician times and spread in Silurian times all over southern Norway and Sweden.

During the summer of 1898 Dr. Holtedahl spent five weeks on Bear Island. The results of his investigations were embodied in his paper "On the Paleozoic Series of Bear Island, Especially on the Heclahook System," forming part II of Volume V of the Norsk Geologisk Tidsskrift. In this paper he adds *Maclurites* sp. and *Gonioceras nathorsti* Holtedahl (Holtedahl, Plate XIV, fig.) to his former list of fossils from the *Tetradium* limestone of Bear Island, figuring both species. In addition he figures a vertical section of an Actinoceroid identified as *Actinoceras bigsbyi* Bronn (=*A. tenuifilum* Hall?) (Holtedahl, Plate XIII, fig. 5); the latter is refigured in the present paper and the term *Actinoceras tenuifilum ursinum* is proposed for it in allusion to its occurrence on Bear Island. Moreover, for the species figured in the preceding paper as *Orthoceras* (*Kionoceras*?) sp. (Holtedahl Plate XI, fig. 2), the name *Kionoceras holtedahli* also is proposed here.

However, the chief new feature of the second paper by Dr. Holtedahl on the Geology of Bear Island is the proof which it brings of the presence of Canadian strata on that island. These species occur in the younger dolomite series of the Heclahook System, beneath the *Tetradium* limestone horizons. The following forms are listed: *Calathium* cf. *pannosum* Billings, *Calathium* sp., *Archaeoscyphia* (*minganensis* Billings?) sp., Crinoid stems, *Maclurites* sp., *Liospira* sp., *Lophospira* sp., *Orthoceras* sp., Cyrtoceraconic shell, and *Piloceras* cf. *explanator* Whitfield (Holtedahl, Plate XII, fig. 6; see also Plate XIII, fig. 3). The significant genera of this list are *Calathium*, *Archaeoscyphia*, and *Piloceras*, which Dr. Holtedahl recognized not only as characteristic of the Canadian but as having their main distribution in Newfoundland and in Eastern Canada.

In the present paper the species listed by Dr. Holtedahl as *Orthoceras* sp. Holtedahl (Plate XIII, fig. 1), is refigured as *Protocycloceras* cf. *lamarcki* (Billings), and the *Cyrtoceraconic shell of uncertain genus* (Holtedahl Plate XIII, fig. 2) is refigured under *Deltoceras* (?) sp., to indicate its Nautiloid character and not because its genus is definitely known.

On Bear Island the younger dolomite series of the Heclahook system is underlaid by the slate-quartz series, and the latter by the older dolomite series. These older dolomite rocks contain oolitoids and stromatolites, both chemical precipitates of carbonate of lime induced by the chemical activities of primitive plants; some of the stromatolites are of the *Cryptozoon* type, others are of the *Gymnosolen* type. The lower dolomitic rocks are correlated with the Ozarkian of North America.

From these studies by Dr. Holtedahl it is evident that three American series of Ordovician rocks had a wide distribution in Arctic areas; these are the Ozarkian, Canadian, and Black River. All three are recognized on Bear Island, and all three appear to have their lithological equivalents on Spitzbergen. Moreover, the two lower series appear to be represented also in Finmarken at the extreme northern end of Norway. Here the Ozarkian or older dolomite series of Bear Island is represented by the Porsanger series, and the Canadian or younger dolomite series of Bear Island finds its equivalent in the Varanger and Raipas series.

The Canadian age of the strata exposed at Durness, in the extreme northwestern corner of Scotland, has been known for a long time owing to the occurrence there of the very diagnostic species *Piloceras invaginatum* Salter. *Orthoceras mendax* Salter is an annulated form with a relatively large subcentral siphuncle which may turn out to be a *Protocycloceras*, a typical Canadian genus. Three species with very oblique annulations occur; these are *Orthoceras baculoides* Blake, *Orthoceras durinum* Blake and a form identified as *Orthoceras arcuoliratum* (?) Hall. In *Orthoceras durinum* the siphuncle probably is marginal. The general aspect of these species is Canadian. If their siphuncles were better known they probably would prove related to the *Endoceratidae* rather than to the *Orthoceratidae*. *Orthoceras pertinens* Blake, however, appears to be a typical *Orthoceras*. Among other forms identified from the Durness limestone are *Ophileta compacta* Salter and *Maclurites matutinus* (?) Hall, both of which are typical Canadian forms.

The species listed by Wyatt-Edgell as *Endoceras eoum* and described by Blake as *Orthoceras* (*Conoceras*) *eoum*, from the Arenig of Shelve, in the western part of Salop county, in Wales, also has a Canadian aspect. The siphuncle is marginal and equals two-sevenths of the diameter of the conch. On reaching the siphuncle the septa "bend slightly upward toward the aperture; though the chambers here stop short, the septa are continued over the siphuncle slightly bending upward, and along the latter is a depressed line." On the relationship of this species Blake adds: "This can not be an *Endoceras*, as the septa certainly do not make sheaths pointing backwards." Apparently this shell bears some resemblance to *Ellesmeroceras scheii* described in the present paper from Bache Peninsula.

Such species as *Actinoceras cochleatum* (Schlottheim), *Endoceras festinans* Blake, and the form identified as *Endoceras brongniartii* Troost suggest the Black River age of the Bala beds of Great Britain. The Llandeilo fauna of the Girvan district also contains American elements, such as *Maclurites logani*, a typical American Black River form.

On continental Europe, however, in the Scandinavian-Baltic areas, Ordovician faunas quite distinct from the American types prevail, as though some barrier had intervened, forming an eastern limit to the American Ordovician seas.

These conclusions are expressed by Dr. Holtedahl in the following terms:

> In the Bear Island a fauna occurs of which we can say that it is no more closely connected with the Scandinavian-Esthonian than are the American equivalent faunas themselves. In the writer's opinion this fact gets its most probable explanation by assuming a land barrier between two different districts of sedimentation of middle Ordovician time, the one characterized by an American-Arctic, the other by a Scandinavian-Baltic faunal element. The many facts pointing towards the existence—at a corresponding time—of a land mass to the northwest of the northernmost, stratigraphically more fully known districts of Southern Norway and Sweden, the Mjösen district in Norway and Jemtland of Sweden, support this supposition. In Scotland a land is generally assumed to have been present in middle Ordovician time in

the far northwest, while further to the southeast the marine Llandeilian strata were deposited. Here we find the interesting Girvan deposits in which certain American faunal elements can be traced.

Regarding the place of origin and the early centers of distribution of gasteropods and cephalopods Dr. Ulrich has submitted the following observations:

> The oldest, in everywise unquestionable, fossil record of the coiled gasteropods and cephalopods is found in Ozarkian rocks. In fact these classes constitute the most important parts of the middle and later faunas of this period as developed in the Mississippi Valley. As but few species of these classes are found elsewhere in rocks of this age, it is assumed that the gasteropods and cephalopods originated in oceanic basins to the south of the Mississippi embayment, that is in the Gulf of Mexico, Caribbean Sea or South Atlantic. From there they spread to the north and west, attaining before the close of the Canadian period rather general distribution in the continental seas of North America. However, judging from the Baltic section, they seem not to have reached the European side of the Arctic until well into the Ordovician (post-Canadian). About the same time, or perhaps in the somewhat later Black River epoch, certain types of cephalopods, like *Gonioceras*, spread from the Arctic into the Pacific. (Revision of the Paleozoic Systems, Bull. Geol. Soc. America, 22, 1911, p. 503.)

Regarding the crinoids, Dr. Ulrich states:

> The crinoids seem to have originated during the early Ordovician (post-Canadian) in the southern middle Atlantic, where the dominant types, as expressed in the invading Gulf faunas of this age are Dendrocrinidae, Hybocrinidae, and Rhodocrinidae. During the Silurian the Gotland crinoids, like the corals, spread freely through the Arctic and then southward in America to northern Illinois. They extended also southward into England, where a slightly different development obtained, and thence into the Atlantic to the Gulf of Mexico and the Mississippi embayment. All the succeeding Paleozoic crinoid faunas, so far as known, originated in and spread from the Atlantic basins. (Ibid., p. 502.)

Regarding the time of origin of the crinoids it is interesting to note that, according to Dr. Holtedahl, fragments of silicified

crinoid stems are common in the Canadian strata of Bear Island. Moreover, fragments of crinoid stems are common also in some of the rock specimens belonging to the Black River strata of Bear Island.

In view of the wide distribution of Black River strata in Arctic areas it is interesting to observe that only three species of crinoids have been described so far from American Black River strata, and all of these were found in the northern part of the Mississippi embayment. These 3 species are *Carabocrinus dicyclicus* (Sardeson) from the Decorah of St. Paul, Minnesota, and of Ellsworth, Wisconsin; *Cremacrinus punctatus* Ulrich from the Decorah of Minneapolis, Minnesota; and *Porocrinus pentagonius* Meek and Worthen from the Platteville of Dixon, Illinois. In the matrix of the Black River strata in the Boothia Felix-King William Land area and from the Cape Chidley area in northern Labrador, only very depauperate stems of crinoids or cystids occur. Unfortunately it is not known on what basis the Bear island Canadian and Black River stems were interpreted as crinoidal rather than as cystidean. That cystidea are of much earlier origin than crinoidea has long been known.

Among the Silurian faunas invading North America by way of the Mississippi embayment are the Brassfield, typical St. Clair, Osgood, Rochester, Waldron, and Brownsport, while the Waukesha, Racine, Lockport, and Guelph represent invasions from the north. (Ulrich, ibid., pp. 558–561). Regarding the migration of Gotlandian faunas from Scandinavian-Baltic areas across the Arctic into the Racine seas of Wisconsin and adjacent Illinois, it is unfortunate that our knowledge of Niagaran faunas in Arctic areas still is so inadequate. In my opinion, no equivalent of a Gotlandian fauna has been recorded so far in American Arctic regions.

From Offley Island, at the mouth of Petermann's Fjord on the west coast of Greenland, at 81°16′ north latitude, came the forms described and figured by Foord as *Orthoceras arcticum* Foord and *Orthoceras darwini* Billings. The first of these is a cyrtoceraconic shell closely allied to an undescribed form in the Racine of the Wisconsin area, while the second is the familiar

Kionoceras myrice Hall and Whitfield from the Cedarville of Ohio which is the Ohio equivalent of the Racine of Wisconsin. *Actinoceras backi* Stokes was identified by Foord from Bessels Bay, about 20 miles southwest of Offley Island, and from Cape Louis Napoleon, 120 miles southwest of Bessells Bay and 35 miles northeast of Bache Peninsula. Another *Actinoceroid* was found at Dobbin Bay, directly west of Cape Louis Napoleon.

Trochoceras boreale Foord was described from Wellington Channel, between North Devon and Cornwallis Islands. It appears related to the Ordovician *Eurystomites* among the *Tarphyceratidae*. *Orthoceras griffithi* Haughton, a vertically striated species, was described from Griffith's Island, south of the middle of Cornwallis Island. *Endoceras ommaneyi* Salter was described from Assistance Bay, on the southern coast of Cornwallis Island. According to Haughton it was a cyrtoceraconic shell.

Actinoceroids appear to be relatively common on Southampton Island, which blocks the northern end of Hudson Bay, and Actinoceroids are common also in the Silurian areas west of Hudson and James Bays.

To me the affinities of these American Arctic cephalopods are with American forms, especially of Racine and Drummond Island type, and not with those of the Scandinavian-Baltic areas. However, such a minute part of the great Arctic regions has been investigated so far that it easily is possible for Silurian zones of European facies to turn up elsewhere in Arctic areas some time in the future. The vastness of these Arctic areas may be realized from the fact that Greenland is as long as the distance from Ottawa in Canada to Cuba; Baffin Land is as long as the distance from Cincinnati, Ohio to Portland, Maine. Ellesmereland is as long as the distance from Cincinnati to the Gulf of Mexico. At least half a dozen of the lesser islands equal in size at least two-thirds of that of the state of Ohio. Evidently there are innumerable possibilities of future discoveries.

The present paper was inspired by Dr. Holtedahl's extremely important communications on the geology of various Arctic areas, briefly reviewed on the preceding pages. While engaged on the study of Arctic Ordovician and Silurian cephalopods the

writer has felt continually the necessity of bringing together from various sources all available material for purposes of direct comparison. In view of the extreme rarity of Arctic cephalopod material, especially from some of the horizons and localities studied by Dr. Holtedahl, the writer requested the loan of such cephalopods as were at hand, and to the kindness of Dr. Holtedahl I owe the privilege of reexamining the material already once worked over by him. While the following pages do not add materially to the observations made by Dr. Holtedahl it is hoped they may be of some service owing to more detailed description and additional illustrations of the cephalapods.

As will be noticed in the following descriptions, most of the Arctic specimens here considered present sufficient detail to be of interest, and yet fall short of furnishing enough evidence for definite specific or, in a few cases, for generic reference. The lack of definite knowledge of the relation of the siphuncle to the cross-section of the conch in the *Actinoceroids*, and of the structure of the siphuncle in the supposed *Cyclendoceroids*, is especially unfortunate. What here is attempted is to secure all available evidence from such material as actually is at hand, in the hope that sooner or later it may lead to the securing of additional material. Such differences of opinion as here are expressed are made possible by lack of sufficient evidence, and evidently would disappear if more complete material could be secured.

LIST OF SPECIES

Gasteropoda, Canadian

1. Cf. Euconia quebecensis Billings.

Cephalopoda, Canadian

2. Clarkoceras holtedahli Sp. nov.
3. Eremoceras syphax (Billings); type.
4. Ellesmeroceras scheii Gen. et Sp. nov.
5. Protocycloceras lamarcki (Billings); types
6. Protocycloceras whitfieldi Ruedemann.
7. Protocycloceras cf. lamarcki (Billings); Bear island form.
8. Deltoceras (?) sp.
9. Kionoceras laqueatum (Hall); type.

Black River and Trenton

10. Kionoceras holtedahli Sp. nov.
11. Kionoceras trentonense Sp. nov.

12. Kionoceras sp.; from Trenton of Middleville, New York.
13. Kionoceras kentlandense Kindle and Breger.
14. Leurorthoceras hanseni Gen. et Sp. nov.
15. Leurorthoceras chidleyense Sp. nov.
16. Actinoceras tenuifilum (Hall); types.
17. Actinoceras sp.; Boothia Felix-King William Land area.
18. Actinoceras amundseni Sp. nov.
19. Actinoceras sp.; Holtedahl's figured specimen.
20. Actinoceras sp.; Boothia Felix-King William Land area.
21. Actinoceras tenuifilum centrale Var. nov.; New York.
22. Actinoceras cf. tenuifilum centrale; Boothia Felix-King William Land area.
23. Actinoceras tenuifilum ursinum Var. nov.
24. Actinoceras parksi Sp. nov.
25. Cyclendoceras annulatum (Hall).
26. Cyclendoceras or Dawsonoceras.

Ordovician age uncertain.

27. Eurystomites (?) boreale Foord.

Helderbergian

28. Orthoceras sp.

1. Cf. **Euconia (?) quebecensis** (Billings)

Plate XXVII, fig. 1

Pleurotomaria quebecensis Billings, Pal. Foss. 1, Geol. Surv. Canada, 1865, p. 190, fig. 174.

Pleurotomaria (Euconia?) quebecensis Bassler, Bibliographic Index of Am. Ordovician and Silurian Fossils, 1915; gen. ref.

Height of shell 17 mm.; apical angle 62 degrees. Volutions about 9, surrounding a deep conical umbilicus having an apical angle of about 30 degrees. Vertical sections of the volutions tend to have a trapezoidal outline. In these sections the outer surface of each volution is moderately convex. The inner surface, of each volution along the umbilicus, is very slightly convex along its upper half, but along its lower half it is very strongly convex curving strongly outward at its base. The line of contact between successive volutions curves slightly downward along most of its length but at its outer extremity there is a slight tendency toward reversal of curvature. The shell is very thin, but distinctly outlined in the matrix. The specimen consists chiefly of a vertical section through the center of the

spire, but at its base it exposes a short part of the length of the two lower volutions.

Locality and Horizon.—From the *Orthoceras* limestone at Victoria Head on Bache peninsula, in Ellesmereland, west of Smith Sound. The horizon is regarded as of Canadian age. In the Palaeontologisk Museum, Kristiania, Norway. Collected by Per Schei in May, 1899, on the Second Polar Voyage of the "Fram" under Captain Sverdrup.

Remarks.—Since typical *Euconia* is of Canadian and Chazyan age it would be interesting to discover this genus in the *Orthoceras* limestone of Victoria Head. In its apical angle and in the large size of its open umbilicus the species here figured and described resembles the vertical section of *Pleurotomaria* (*Euconia*?) *quebecensis* figured by Billings, but here the resemblance ends. The Victoria Head specimen has an extremely thin shell, there is no trace of lines of growth or of a slit-band, and the inner outline of the volutions is much more angular.

2. **Clarkoceras holtedahli** Sp. nov.

Plate XXVII, figs. 2A, B; Plate XXXIII, fig. 1

Specimen consisting chiefly of the upper part of the phragmacone; to this is attached that part of the basal portion of the living chamber which is adjacent to the siphuncle. The phragmacone is estimated to have had a height of at least 60 mm. The dorso-ventral diameter at the base of the living chamber is estimated at 47 mm., and the dorso-ventral apical angle was between 35 and 40 degrees. The conch is strongly compressed laterally, the lateral diameter at the base of the living chamber being estimated at 25 mm. The conch is slightly curved lengthwise in a dorso-ventral direction. The location of the siphuncle is endogastric, or on the concavely curved side of the conch. Here the curvature equals about 1 mm. in a length of 25 mm. The opposite side of the conch is curved in a convex direction, apparently at about the same rate as the concavely curved side.

Five camerae occupy a length of 16 mm., measured along the lateral side of the specimen; 2 additional camerae of about the

same height are exposed in the vertical section exposing the siphuncle; this is followed by a shorter camera, and a trace of a second shorter camera. From this it is concluded that the conch was mature. The sutures of the septa are directly transverse to the axial diameter of the conch. At the base of the specimen the dorso-ventral curvature of the septum has a radius of 25 mm., and its radius of lateral curvature is scarcely 12 mm. The siphuncle is almost in contact with the adjacent wall of the conch. At the base of the living chamber the dorso-ventral diameter of the siphuncle is about 7 mm., or about one-seventh of the dorso-ventral diameter of the conch. At the base of the specimen the dorso-ventral diameter of the siphuncle is slightly over 4 mm. The segments of the siphuncle intercepted between successive septa present slightly concave vertical sections along their walls. The lower margin of one segment invaginates into the upper part of the segment next beneath. The thickness of the siphonal wall is greater than that of the septa. There is no trace of an endocone.

Locality and Horizon.—From the *Orthoceras* limestone on Victoria Head, at the northeastern angle of Bache Peninsula; regarded as of Canadian age. Collected by Per Shei in May, 1899. Deposited in the Palaeontologisk Museum, Kristiania, Norway.

Remarks.—This species almost certainly is congeneric with *Clarkoceras newton-winchelli* (Clarke), although it has not been possible to prove that the segments of the siphuncle are annular connecting rings, and not prolongations of the septal funnels as in the *Endoceratidae*. In *Cyrtocerina* the interior of the siphuncle has transverse ridges alternating with the septa between the camerae. I do not know the structure of *Cyrtocerina* well enough to determine whether this appearance of internal transverse ridges indicates a structure generically different from that of *Clarkoceras*. In such specimens of *Cyrtocerina* as I have seen only the casts of the interiors of the camerae have been retained, the substance of the siphuncle having disappeared.

Clarkoceras newton-winchelli is from the Shakopee division of the Canadian in Union township in Houston county, Minnesota.

The type of *Cyrtocerina*, namely *Cyrtocerina typica*, is from the Leray division of the Black River at Pauquette Rapids, on the Ottawa River, in Canada. A second species, *Cyrtocerina mercurius*, was described by Billings from the Levis division of the Canadian at Point Levis, in Quebec, Canada. A third species, now known as *Cyrtocerina madisonensis*, was described by Miller from the Saluda member of the Richmond at Madison, Indiana, and a fourth species, *Cyrtocerina* (?) *schoolcrafti*, was described by Clarke from the Decorah division of the Black River near Cannon Falls, Minnesota. It is not certain that all of these are congeneric.

Among all these species, the relationship of the Victoria Head species described above, under the name *Clarkoceras holtedahli*, appears nearest to the Canadian genotype, *Clarkoceras newton-winchelli*, thus favoring the Canadian age of the enclosing strata at Victoria Head.

3. **Eremoceras syphax** (Billings)

Plate XXXIII, figs. 8 A, B, C; fig. 2

Cyrtoceras syphax Billings, Pal. Foss., 1, Geol. Surv. Canada, 1865, p. 194, text fig. 178.

Eremoceras syphax Hyatt, Proc. Boston Soc. Nat. Hist., 22, 1884, p. 282, Genotype.

Type specimen.—Conch slightly curved lengthwise along its dorsal side, the radius of convex curvature of the latter being about 100 mm. The ventral side is either straight or too faintly concave to be measured for curvature, at least in the type specimen. This specimen consists of the living chamber with 11 camerae and part of a twelfth camera still attached. The height of the living chamber is 18 mm. along its dorsal side; the margin of the aperture slopes gently downward from the dorsal toward the ventral side, so that the height of the living chamber along its ventral side is estimated at about 15 mm. The upper part of the shell of the living chamber is thickened slightly interiorly for a distance of 8 mm. from the aperture. On the cast of the interior of this chamber this thickening of the shell is indicated by a slight constriction of the upper part of the cast.

The conch is compressed laterally, the lateral diameter at the aperture being 19 mm., the dorso-ventral one being estimated at 23 mm. The corresponding diameters at the base of the living chamber are 16 and 19 mm. respectively. The lower 9 camerae occupy a length of 14 mm.; the upper 3 camerae, however, occupy a length of only 3.8 mm., each being successively shorter and the uppermost being only 1 mm. in length, thus indicating that the specimen was mature.

Along the dorsal side of the conch the sutures of the septa are almost directly transverse. On the lateral sides they curve at first gently downward, and then, on approaching the siphuncle, the sutures rise strongly upward. The septa, as far as known, are only moderately concave. The siphuncle has a lateral apical angle of 15 degrees. At the base of the living chamber its lateral diameter is 7 mm. At the base of the specimen its lateral diameter is 2 mm. The original length of the phragmacone of a complete specimen may have been 20 mm. The ventral side of the siphuncle apparently was in contact with the ventral wall of the conch along almost its entire width, thus agreeing with the latter in its lateral curvature. Along the side facing the interior of the conch, the siphuncle was more convex laterally, so that the cross-section of the siphuncle must have resembled somewhat that of a *Tripteroceras*, in the flattening of one side and the greater convexity of the opposite side. Between successive septa the walls of the siphuncle curve slightly inward, suggesting an Endoceratitic structure, successive funnels extending downward the length of one camera and invaginating into the neck of the funnel next beneath.

The cast of the interior of the conch is marked by faint vertical ribs, both on the phragmacone and on the living chamber, there being possibly 35 or 40 ribs within the circumference of the living chamber. Along the living chamber there are also several very faint annulations, with crests about 3 mm. apart. These annulations slope downward from the dorsal toward the ventral side of the conch at an angle agreeing with that of the margin of the aperture, but at a rate greater than that of the sutures of the septa. Whether these very obscure vertical ribs and transverse

annulations indicate corresponding markings on the exterior of the shell is unknown.

Locality and Horizon.—Found at Point Levis, Quebec, in the Levis representative of the Canadian formation. Type, numbered 819, in the collections of the Geological Survey of Canada.

Remarks.—The preceding description of the type of *Eremoceras syphax* differs necessarily from those previously presented, since only the dorsal side was exposed when the specimen was studied by Billings and Hyatt. Recently, however, the writer removed all of the surrounding matrix, thus exposing for the first time the large siphuncle, What formerly had been regarded as the siphuncle apparently was a slight discoloration along the median line of the dorsal side, and this had been emphasized by vertical scratches made in an attempt to learn more of the supposed siphuncle.

4. **Ellesmeroceras scheii** Gen et. Sp. nov.

Plate XXVII, figs. 3 A, B, C; Plate XXXIII, fig. 3

Conch straight along the ventral side and presumably straight also along the dorsal side as far as may be determined from the specimen at hand. Apical angle small, probably about 8 degrees in a dorso-ventral direction. Conch compressed laterally. At the base of the living chamber the dorso-ventral diameter is estimated at 12 mm.; the lateral diameter is 10.5 mm.

The number of camerae in a length equal to the dorso-ventral diameter of the conch at the top of the series of camerae being counted is 10. Since the uppermost camera has about the same length as the camerae immediately beneath, it is not certain that the conch is mature. The sutures of the septa slope from the siphuncle along the median line of the ventral side downward toward the dorsal side, curving in a slightly sigmoid manner. Along the middle of the lateral sides of the conch the sutures form an angle of about 80 degrees with the vertical axis; toward the siphuncle the sutures rise more rapidly and toward the dorsal side of the conch they descend more rapidly than along the middle of the lateral sides.

The siphuncle is narrow and is in contact with the ventral wall of the conch; apparently it is slightly flattened by its contact with the latter. At the base of the specimen, where the diameter of the conch is estimated at 9 mm., the diameter of the siphuncle is about 1.4 mm. in a lateral direction. Laterally the segments of the siphuncle present slightly concave vertical outlines. If these segments represent downward continuations of the septal necks, then the latter descend the length of a single camera and they invaginate into the top of the septal necks next beneath. No trace of surface ornamentation is preserved.

Locality and Horizon.—From the *Orthoceras* limestone at Victoria Head on Bache peninsula, on Ellesmereland, west of Smith Sound. Regarded as of Canadian age. In the Palaeontologisk Museum, Kristiania, Norway. Collected by Per Schei in May, 1899.

Remarks.—The species here described as *Ellesmeroceras scheii* has about the same apical angle as *Endoceras montrealense* (Billings) as figured by Ruedemann (Bull. New York State Museum, 1906, p. 424, pl. 9, fig. 8); the number of its camerae is also about the same, but in the latter species the sutures of the septa curve distinctly downward on approaching the siphuncle along the median part of the ventral side of the conch, and the relative size of the siphuncle is much greater.

In the upward curvature of the sutures of the septa on approaching the siphuncle *Ellesmeroceras scheii* resembles *Eremoceras syphax* but the apical angle of the latter is much greater, its form is slightly cyrtoceraconic due chiefly to lengthwise curvature along the dorsal side, and the siphuncle is much larger, tapers much more rapidly toward its apical end, and is appressed for a greater part of its width against the ventral wall of the conch.

Ellesmeroceras is regarded as a straight Endoceratitic shell with a relatively small siphuncle; the sutures rise on approaching the siphuncle, and the latter is in contact with the ventral wall of the conch. In true *Endoceras* the sutures do not rise in a conspicuous manner on approaching the siphuncle but are more nearly directly transverse. While I am doubtful as to the gen-

eric value of the differences noted above, the Ellesmereland specimen here described does not appear to me to be a typical *Endoceras;* the absence of any trace of *endocones* is certainly generic, if constant; hence the new generic term *Ellesmeroceras*, with *Ellesmeroceras scheii* as the genotype is here proposed.

Conchs with siphuncles in contact with the ventral wall are fairly common in the Canadian strata of eastern Canada and in the adjacent parts of the United States. Most of these forms are smooth but some are annulated. Most species are straight but curved forms also occur. Among smooth forms with relatively small siphuncles may be mentioned the species described by Billings as *Orthoceras cato*, *O. repens*, and *O. perseus*. The latter is laterally compressed. *Orthoceras sordidum* may belong here also. In *Orthoceras autolycus* the conch is slightly curved lengthwise.

Conchs with siphuncles in contact with the ventral wall occur also in the Ozarkian but most of these are more or less distinctly curved lengthwise.

The number of these early cephalopods in which the segments of the siphuncle show concave lateral outlines also is of interest. This type of outline is noted in *Eremoceras syphax* and *Ellesmeroceras scheii*. It is seen also in *Cyclostomiceras cassinense* (Whitfield). It is figured by Ruedemann in *Orygoceras cornuoryx* (Whitfield), *Protocycloceras whitfieldi* Ruedemann, and *Endoceras montrealense* (Billings). It was noted by Billings in the species described by him as *Orthoceras menelaus*, *Orthoceras indegator*, and *Orthoceras flavius*, the last two of which have the siphuncle in contact with the ventral wall, as in *Endoceras montrealense*. The number of such Canadian and Ozarkian cephalopoda with siphuncular segments presenting vertical lateral outlines is considerably multiplied if cyrtoceraconic forms be included. This type of outline appears to occur chiefly in Holochoanitic forms, but a reëxamination of all forms having this type of siphuncle is necessary.

As far as can be determined from the preceding observations, the occurrence of *Clarkoceras holtedahli* and *Ellesmeroceras scheii* in the *Orthoceras* limestone at Victoria Head suggests that this limestone includes a horizon of Canadian age.

Holtedahl, in his paper on "The Cambro-Ordovician Beds of Bache Peninsula," figures fossils from three horizons. From the sandstones at Cape Camperdown, at the southeastern corner of Bache peninsula, he figures a cranidium, a free cheek, and a pygidium of *Ptychoparia*. From an overlying light greyish-white limestone which crops out midway up the vertical face of Victoria Head he figures a cranidium of *Illaenurus* and one of *Ptychoparia*. From an overlying close-grained brown limestone farther up the Head he figures a pygidium of *Bathyuriscus*, a *Maclurea*, and a *Hormotoma*. The *Clarkoceras* and *Ellesmeroceras* here described were obtained somewhere within the greyish-white limestone mentioned above. Since the total thickness of the latter was estimated by Per Schei at 350 feet, it is possible that more than one horizon here is included. The *Illaenurus* and *Ptychoparia* figured by Holtedahl suggest the Ozarkian age of the including strata, while the cephalopods here discussed suggest Canadian age. It is possible that both horizons are present in the greyish-white limestone at Victoria Head.

5. **Protocycloceras lamarcki** (Billings).

Plate XXXIII, figs. 7 A, B, C, D

Orthoceras lamarcki Billings, Canadian Nat. Geol., 4, 1859, p. 362; Geol. Canada, Geol. Surv. Canada, 1863, p. 121, figs. 38 a, b, c; Pal. Foss. 1, Geol. Surv. Canada, 1865, pp. 255, 347, fig. 336.

Protocycloceras lamarcki Hyatt, Zittel-Eastman Textb. Pal. 1, 1900, p. 518; Ruedemann, Bull. New York State Mus., 90, 1906, p. 441, pl. 15, figs.1–6; pl. 16, figs. 1, 2; figs. 15, 16.

Types.—The first published figure consists of three views of a specimen numbered 550 in the collections of the Geological Survey of Canada, and labelled as coming from lot 12, concession 12, Godmanchester township, in Huntingdon county, Quebec. This specimen is 36 mm. long and has 12 annulations in a length of 33 mm.; the diameter at its upper end is 17 mm.; and its apical angle is about 8 degrees. In preparing the first published figure a mirror camera lucida was used so that in both

figure 38a and figure 38b the direction of lengthwise curvature is opposite to that of the specimen itself. The latter consists of part of a phragmacone, exposing on one side the septa, which are only moderately concave. The sutures occupy the grooves between the annulations, the latter occurring at mid-height of the camerae. The siphuncle is relatively large, having a diameter of 6 mm. at the top of the specimen, where the diameter of the conch is 17 mm.

The second specimen figured by Billings, numbered 7455a in the collections of the Geological Survey of Canada, was obtained in Oxford township, in Greenville county, Quebec. In a length of 57 mm. it contains 20 annulations. The diameter at the top of the specimen is 18 mm.; here the diameter of the siphuncle is 7.2 mm.; and the center of the siphuncle is 8 mm. from the nearest wall of the conch, so that its location is only slightly excentric. In specimen 7456b, from the same locality, the center of the siphuncle is four-elevenths of the diameter of the conch from its nearest wall, thus indicating a greater amount of excentricity. Specimen 7456 consists of a phragmacone 110 mm. long, with an estimated diameter of 23 at the larger end. Full grown specimens probably attained diameters of at least 30 mm.

Specimen 550b, from the same locality as the first figured specimen, apparently has funnels descending for at least the depth of one camera.

Specimens 508 and 508a, from Romaine on the Gulf of St. Lawrence, apparently indicate obscurely that the lower end of each funnel is inserted for a short distance into the top of the funnel next beneath.

Locality and Horizon.—Found in various counties in the eastern part of the province of Quebec, and on the Mingan islands and on Newfoundland, in the Canadian formation. Also in the Beekmantown of New York.

6. **Protocycloceras whitfieldi** Ruedemann

Plate XXXIII, fig. 4

Orthoceras bilineatum, Whitfield, Bull. Amer. Mus. Nat. Hist., 3, 1890, p. 35, pl. 2, fig. 5, fig. 17 *a*, *b*.

Protocycloceras whitfieldi Ruedemann, Bull. New York State Mus. Nat. Hist., 90, 1906, p. 443, fig. 17*a*, pl. 15, fig. 7.

In a specimen of *Protocycloceras whitfieldi* Ruedemann, from the Fort Cassin beds at Fort Cassin, Vermont, the structure of the siphuncle is more distinctly shown. At the septal neck of the funnel, the latter bends abruptly downward; the funnel contracts downward in one specimen from a diameter of 7 mm. at the neck to 6.3 mm. a little below the middle of the camera beneath, expanding to 6.5 mm. at its lower margin, which descends for a distance equalling about one-fourth of the height of a camera into the upper part of the funnel next beneath. In longitudinal sections, the siphuncle appears broadly annulated at the septa, with very shallow intermediate grooves which have their maxima of contraction slightly beneath mid-height of the camerae. No distinct markings were noticed on the surface of either *Protocycloceras whitfieldi* or of *Protocycloceras lamarcki*.

7. **Protocycloceras** cf. **lamarcki** (Billings)

Plate XXVII, fig. 5; Plate XXXIII, fig. 5A, B

Orthoceras ? sp., Holtedahl, Paleozoic Series of Bear Island, 1919, p. 129, pl. 13, fig. 1.

Conch enlarging very slowly, from 13.3 mm. to 14.6 mm. in a length of 18 mm. The lower 4 camerae occupy a length of 10 mm.; and the upper 5 camerae, of 14 mm. The sutures are assumed to have been directly transverse though they are not exposed for a sufficient distance around the circumference of the conch to permit the determination of their course with exactness. The septa are moderately concave, curving downward a distance of 2 mm. where their diameter is 14 mm. The siphuncle is relatively large, being 5 mm. in diameter where the diameter of the conch is 14.5 mm. The position of the siphuncle

is nearly central, one side being 4.5 mm. from the nearest wall of the conch while the other side is 5 mm. distant from the opposite wall. Within each camera the enclosed segment of the siphuncle appears to become narrower in a downward direction, curving slightly inward so as to present slightly concave vertical outlines. Apparently the lower margin of each segment of the siphuncle invaginates into the top of the septal neck next beneath. Apparently also the surface of the shell is slightly annulated, the crests of the annulations coinciding with mid-height of the camerae.

Locality and Horizon.—Collected 1 kilometer west of Norskhavna, or 1.4 kilometers north-north-west of the northern margin of South Harbor on Bear Island, July 1918, by Olaf Holtedahl. In the Palaeontologisk Museum, Kristiania, Norway. Original of Fig. 1 on plate II of Holtedahl's paper on the Paleozoic Systems of Bear Island. From the younger dolomite series, in the Heclahook System of strata, corresponding to the Canadian of North America.

Remarks.—The specimen from Bear Island is too poorly preserved for exact determination, but its annulation, though slight, and its large subcentral siphuncle with segments narrowing in a downward direction suggest affinities with *Protocycloceras lamarcki*. At least the resemblance is sufficient to suggest the Canadian age of the enclosing strata on Bear Island. The original identification of these Bear Island strata as Canadian was based by Holtedahl on the association in the same strata of such characteristic genera as *Calathium*, *Archaeoscyphia*, and *Piloceras*. The Bear Island *Calathium* resembles *Calathium pannosum* Billings, an Ozarkian species from Point Levis, Quebec, and the *Piloceras* is closely related to *Piloceras explanator* Whitfield from the Beekmantown member of the Canadian in Vermont and New York. *Archaeoscyphia* is listed from the Canadian of the Mingan Islands, in Canada.

8. **Deltoceras** (?) sp.

Plate XXVII, fig. 6; Plate XXXIII, figs. 6A, B, C

Cyrtoceraconic shell of uncertain genus, Holtedahl, Paleozoic Series of Bear Island, 1919, p. 130, p. 13, fig. 2.

Nautiloid shell, with volutions strongly compressed laterally, the dorso-ventral diameter of the specimen being 33 mm.; and the lateral diameter 20 mm. The siphuncle is cylindrical in form and slightly over 3 mm. in diameter; its center is 5.5 mm. from the ventral wall of the volution. That part of the siphuncle which is exposed in the specimen is crossed at mid-length by a single complete septum having a concave curvature of about 7 mm. The ventral fourth of another septum is preserved 10 mm. from the first septum, on its orad side. Owing to the angle at which this part of the specimen has been cut, the passage of the siphuncle through this second septum is not retained. A third septum is exposed on the apical side of the first mentioned septum, at a distance of 11 mm. from the latter. This third septum is the one exposed in the figure presented by Holtedahl, cited above. Judging from the small curvature of the siphuncle and of the ventral wall of the specimen at hand, the complete phragmacone could easily have equalled 150 mm. in diameter measured across the volutions, and the complete shell probably was considerably larger.

From the curvature of the septum at the apical end of the specimen it is evident that the sutures of the septa had broad lateral lobes and also dorsal and ventral saddles; the general appearance of the saddles must have been affected by the strong lateral compression of the conch. It can not be determined definitely from the small fragment at hand whether the specimen was transversely ribbed or not, but it is assumed that no pronounced ribbing was present. Moreover, there is no evidence of an impressed zone along the dorsal side of the specimen due to contact with the ventral side of preceding volutions.

Locality and Horizon.—Collected 1 kilometer west of Norskhavna, or 1.4 kilometers NNW of the northern margin of South Harbor, on Bear Island, by Olaf Holtedahl, in July, 1918. Depos-

ited in the Palaeontologisk Museum at Kristiania. Original of fig. 2 on plate 13 of Holtedahl's paper, cited above. From the younger Dolomite series, in the Heclahook System of strata, corresponding to the Canadian of North America.

From such a small fragment it is impossible to determine with confidence the generic relationship of this species, but it evidently belongs to the *Tarphyceratidae*.

9. **Kionoceras laqueatum** (Hall)

Orthoceras laqueatum Hall, Pal. New York, 1, 1847, p. 13, pl. 3, fig. 12.

Type.—Apical angle about 9 degrees. Diameter at the top of the specimen estimated at 9 mm. In a letter Dr. Ruedemann states regarding this specimen that "The *Orthoceras laqueatum* shows 11 vertical ribs on the visible half. Since that is not quite the entire half, I should judge there were 20 ribs on the shell. There is always one stria between two ribs." Nothing is known of its interior structure.

Locality and Horizon.—From some unknown locality in the Beekmantown division of the Canadian in New York state. Hall stated that "the position of the specimen is probably at the upper termination of this (Beekmantown) rock, and just at its passage into the succeeding limestone." The type is numbered 12375 in the New York State Museum of Natural History at Albany, New York.

Remarks.—The reference of this specimen to *Kionoceras* must be regarded as tentative. If *Kionoceras* arose from a multistriate ancestral Orthoceroid by the increased prominence of certain of the vertical striae, then *Orthoceras laqueatum* may be regarded as ancestral to typical *Kionoceras*.

10. **Kionoceras holtedahli** Sp. nov.

Orthoceras (Kionoceras?) sp. Holtedahl, Ordovician Fossils from Bear Island, 1918, p. 84, pl. 11, fig. 2.

Judging from the figure published by Holtedahl, the apical angle of the conch is about 4.5 degrees, and the number of verti-

cal ribs is somewhere near 32; about 4 camerae appear to occupy a length equal to the diameter of the conch at the top of the series of camerae being counted, but Holtedahl states that the distance between the septa is one-fifth of the diameter of the shell. The vertical section of the lower end of the specimen, as figured by Holtedahl, indicates that the segments of the siphuncle are almost globular, that the diameter of the siphuncle equals almost one-fourth of that of the conch, and that its center is about one-third of the diameter of the conch from its ventral wall. In describing the ornamentation on the surface of the shell Holtedahl states that the "longitudinal ridges, though not much elevated, have a rather sharp section. In some places there seems to be present a faint ridge in the middle of the interval between the ridges and possibly an indication of other, extremely faint ones."

Locality and Horizon.—From the Antarctic Mountain area in the southern part of Bear Island. From the *Tetradium* limestone at the top of the Heclahook system. This limestone is regarded as of Black River age. In the Riksmuseet, Stockholm, Sweden.

Remarks.—At least two undoubted specimens of *Kionoceras* occur in strata below the Richmond in American areas, namely *Kionoceras kentlandense* from the Black River area in northwestern Indiana and a lower Trenton form from New York described by Hall under *Orthoceras laqueatum* ? *var. a.* Three other species, typical *Orthoceras laqueatum* from the Beekmantown of New York, a similar species from the Leray at Pauquette Rapids, Canada, and the specimen here described as *Kionoceras trentonense* from the middle Trenton at Middleville, New York, may belong to the vertically striated forms from which *Kionoceras* originated. Foord refers to *Orthoceras laqueatum* some imperfectly preserved specimens from the Trenton at Montmorenci Falls, near Quebec, Canada which show "traces of what would appear to have been longitudinal ridges." It is cited also from the Trenton at Frobisher Bay, on Baffin Land.

11. **Kionoceras trentonense** Sp. nov.

Plate XXXV, fig. 1

Orthoceras laqueatum (Hall), Pal. New York, 1, 1847, p. 206, pl. 56, figs. 2 b, c.

Apical angle about 3 degrees. Diameter at top of specimen estimated at 5 mm. Length of specimen 22 mm. At the smaller end of the specimen a septum terminates the specimen. That part of the specimen which in Hall's figure extended beneath this septum consisted of nothing but matrix. The siphuncle, at its passage through the septum, is small and slightly excentric in position. The surface of the shell is occupied by about 20 primary vertical ribs and an equal number of almost equally prominent secondary riblets which alternate with the primary ones. Both ribs and riblets rise acutely above the general surface of the shell. In the grooves between the ribs and riblets there are additional and much finer striae, usually 3, sometimes 4 or 5 in number, and visible only under a lens. Finally, the microscope reveals numerous very fine transverse striae, about 70 in a length of 1 mm. These striae are horizontal along the left third of the exposed part of the shell, they curve rather strongly downward along the middle third and become horizontal again along the right third. It is assumed that the right third of the exposed part of the shell is the ventral side, and that there was a distinct hyponomic sinus whose depth is indicated by the amount of deflection of the transverse striae.

Locality and Horizon.—According to Hall this specimen is from the middle portion of the Trenton at Middleville, New York. The specimen is numbered 802 A in the American Museum of Natural History in New York city.

Remarks.—The Trenton species here described differs from typical *Orthoceras laqueatum* from the Beekmantown in its much smaller apical angle. It is probable that if more were known of the surface markings and internal structure of both forms that other differences would be noted.

A similar specimen, from the Leray member of the Lowville at Pauquette Rapids in Ontario, has 3 camerae in a length

equal to the diameter of the conch, where the latter is 10 mm. At this point the diameter of the siphuncle is 1 mm., and its distance from the dorsal side of the conch is 3.7 mm. The form of the siphuncle is tubular, not enlarging within the camerae. The conch is slightly curved lengthwise, with the dorsal side concave. There are about 40 vertical striae, more or less alternating in size.

Vertically ribbed Orthoceroids of the *Orthoceras laqueatum* type occur also in the Bala beds of Great Britain, where they are known as *Orthoceras lineatum* Hisinger. *Orthoceras striatum* Marcklin, *Orthoceras subcostatum* Portlock, and *Orthoceras striato-punctatum* M'Coy are other terms whose exact value will be understood only after the types have been fully illustrated and described.

12. **Kionoceras** Sp.

Plate XXXV, fig. 2

Orthoceras laqueatum ? *var. a* Hall, Pal. New York, 1, 1847, p. 206, pl. 56, fig. 3.

Specimen 22 mm. long, 7 mm. wide at the base of the specimen and 8 mm. wide at its top, with an apical angle of about 3.5 degrees in a lateral direction. Cross-section elliptical, the diameters at the base being 7 and 4.5 mm. respectively. There is no trace of septa or siphuncle; the specimen therefore may consist of most of a living chamber. The surface of the specimen is marked by 20 vertical ribs, each about a quarter of a millimeter in width, the intervening grooves being three-quarters of a millimeter wide. The crest of the ribs is angular, and the elevation of the ribs is conspicuous, considering the small size of the specimen. The crests of the ribs are crossed by transverse striae, about 13 in a length of 5 mm., but no trace of these striae is noticed in the broad intermediate grooves. Possibly the striation is structural and within the substance of the shell rather than on its surface.

Locality and Horizon.—From the lower shaly strata of the Trenton at Middleville, New York. The matrix of the specimen contains a brachial valve of *Triplecia nucleus* (Hall). The

specimen is numbered 802 B in the American Museum of Natural History in New York city.

Remarks.—The general aspect of the shell with its prominent ribs and broad intermediate grooves is so similar to that of *Kionoceras* that the generic reference may be assumed to be correct. Compared with *Kionoceras kentlandense* Kindle and Breger, from the Black River of northwestern Indiana, the number of vertical ribs is only 2 or 3 less, their number in the Indiana species being 22 or 23. It is probable that the New York Trenton species is distinct from the Indiana Black River form, but in case of the former the interior structure is unknown and in case of the latter the surface features are not preserved.

A specimen similar to the New York species in the number and prominence of its vertical ribs occurs in the Leray member of the Lowville at Pauquette Rapids, in Ontario. There are 22 ribs, and the cross-section is cylindrical. It is 21 mm. long, and enlarges from 3.6 mm. to 4.7 mm. in this length. The siphuncle is half a millimeter in diameter, and its position is almost central.

13. **Kionoceras kentlandense** (Kindle and Breger)

Orthoceras (Kionoceras) kentlandensis Kindle and Breger, 28th Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1904, p. 470, pl. 21, fig. 2.

Type.—The specimen enlarges from 7 mm. at the lower end to 11 mm. at the upper end, the interval being 78 mm., suggesting an apical angle of 3 degrees. Only the cast of the interior of the conch is at hand. This is marked by 22 or 23 vertical ribs which are distinct, though low, along the entire length of the specimen, including the living chamber. At the top of the phragmacone there is a series of 6 camerae successively shorter in length, indicating that the specimen had attained maturity; all 6 of these camerae occupy a total length equal to only ten-ninths of the diameter of the conch. Of the living chamber a length of 17 mm. remains, but this does not include the upper part of the living chamber which, in this genus, should

show a contraction along the upper part of the cast of the interior, a short distance below the aperture. The siphuncle is about 1.25 mm. in diameter at the base of the specimen and its location is somewhat excentric. No trace of the surface markings, beyond the presence of vertical ribs, is present in this type.

Locality and Horizon.—The type is numbered 685 in the State Museum of Indiana, at Indianapolis, Indiana. It occurs in a very fine-grained, brownish-gray limestone having a conchoidal fracture, resembling some phases of the Plattin limestone of eastern Missouri. The same limestone, at Kentland, Indiana, contains *Columnaria halli*, *Rafinesquina minnesotensis*, *Strophomena trentonensis*, *Zygospira recurvirostris*, *Ctenodonta nasuta*, *Actinoceras beloitense*, *Isotelus* cf, *platycephalus*, and *Thaleops ovatus*. This is a typical representative of that fauna in the upper Mississippi Valley which is correlated with the Black River limestone of New York.

14. **Leurorthoceras hanseni** Gen. et Sp. nov.

Plate XXX, figs. 1A, 1B; pl. XXXI, fig. 1; pl. XXXII, fig. 8; pl. XXXIV, fig. 2

Specimen consisting of part of a phragmacone having an apical angle of 14 degrees in a lateral direction and of 4 or 5 degrees in a dorso-ventral direction. The cross-section of the conch is subtriangular. This subtriangular outline is produced chiefly by the strong and broad flattening of the ventral side of the conch and the strong transverse curvature of the shell along its ventro-lateral angles. Along the dorsal half of the conch the transverse curvature is fairly regularly convex, that of the smaller end of the specimen corresponding fairly well to the curvature of a circle 45 mm. in diameter. The dorso-ventral diameter at this smaller end equals 30 mm.

In a length equal to the lateral diameter of the conch there are 6.5 camerae. Along the dorsal half of the conch the sutures are directly transverse, but along the ventral half they curve distinctly downward. At the upper end of the specimen the amount of this downward curvature equals 5 mm. Along the

median part of the shell the curvature of the sutures is evenly concave, but toward the lateral sides they tend to diverge at angles of 155 to 158 degrees. The curvature of these sutures corresponds approximately to that which would result if a normal cylindrico-conical Orthoceroid had one side ground away until a similar subtriangular cross-section were produced. The sutures curve downward a distance of 6 or 7 mm., reaching their lowest level about 7 mm. dorsad of the center of the siphuncle. At the lower end of the specimen where the dorso-ventral diameter of the conch is 30 mm., the narrowest part of the septal necks is slightly less than 5 mm. in diameter. The length of these septal necks is 2 mm. and at their lower margins they curve distinctly outward. Within the camerae the segments of the siphuncle attain a maximum diameter of 9.5 mm. In vertical sections the outlines of these segments tend to be circular rather than broadly nummulitic, at least along the lower part of the specimen. The shell material of the siphuncle appears to have been extremely thin, and only parts of the connecting rings are distinctly preserved, in some camerae more than in others.

No indication of surface markings is retained by the specimen, which is a cast of the interior of the conch.

Locality and Horizon.—From some unknown locality either on Boothia Felix or on King William Land; probably from Black River limestone. In the Palaeontologisk Museum, Kristiania, Norway. Collected in 1903–04 by Lieut. Godfred Hansen in whose honor this species is named.

Remarks.—*Leurorthoceras hanseni* is very similar to *Leurorthoceras chidleyense*, described in this paper, from which it differs in having a smaller apical angle; it is less strongly flattened ventrally, and the segments of the siphuncle are relatively narrower. Both species are congeneric and both are regarded as belonging to a new genus for which the term *Leurorthoceras* is proposed, with *Leurorthoceras hanseni* as the genotype. This is characterized by the flattening of the ventral side of the conch, the broad ventral lobes of the sutures, and the relatively moderate inflation of the segments of the camerae compared with strongly nummulitic forms like *Actinoceras*.

Unfortunately the age of neither *Leurorthoceras hanseni* nor of *Leurorthoceras childleyense* is fully established. In both cases the type specimens occur associated with other specimens of undoubted Black River age, but in each case the *Leurorthoceras* in question consists of a matrix differing lithologically from that of the associated Black River fossils sufficiently to admit of the possibility of the former belonging to a different geological horizon.

Orthoceroids with flattened ventral sides are known also from other localities and horizons but are not known to have the same structural characteristics of the siphuncle as in *Leurorthoceras*.

In *Orthoceras capitolinum* Safford, from the Bigby member of the Trenton at Nashville, Tennessee, according to the figures presented by Safford, the lateral angles of this species are even more angular than those of *Leurorthoceras hanseni*. About 15.5 camerae occupy a length equal to the lateral diameter of the conch at the top of the series of camerae being counted. At the base of the specimen the lateral diameter is 62 mm., the dorso-ventral one is 38 mm., the diameter of the siphuncle at its passage through the septum is 15 mm., and the distance of this siphuncle from the ventral wall of the conch is about half a millimeter. It is difficult to conceive how there could be room here for a strongly nummuloidal siphuncle. I am informed by Prof. L. C. Glenn that the type of *Orthoceras capitolinum* can not be found in the Safford collection at Nashville, Tennessee, and probably has been lost.

Specimens in the U. S. National Museum, identified as *Actinoceras capitolinum*, have undoubted nummulitic siphuncles, 15 to 20 mm. in diameter, in direct contact with the ventral wall of the conch, but not enough of the circumference of the conch is preserved to show the subtriangular cross-section.

In *Orthoceras murrayi* Billings, from the Black River limestone on St. Joseph Island, Lake Huron, the cross-section is more triangular than in any of the species discussed so far. This triangularity is due not only to the flattening of the ventral side of the conch but also to the flattening of the two dorso-ventral sides, producing a distinct line of angularity along the median

part of the dorsal side. Where the lateral diameter of the conch is 40 mm., the dorso-ventral diameter is 30 mm., the passage of the siphuncle through the septa scarcely equals 6 mm., and the distance of this siphuncle from the ventral wall is 2.5 mm. In form, the siphuncle is tubular, not enlarging between the septa. This is at variance with the structure of either *Leurorthoceras* or of *Orthoceras capitolinum*. Along the median part of the dorsal side the sutures curve distinctly upward.

In *Tripleuroceras robsoni* Whiteaves, from Stonewall, Manitoba, and regarded by Whiteaves as Niagaran, the ventral side again is flattened, and the sutures of the septa curve downward here as in *Leurorthoceras*. Moreover, Whiteaves states that in the Manitoba species the sutures are "nearly straight where they pass over the sides." If the term *straight* here is equivalent to *horizontal* then the general appearance of the sutures in this species should be similar to that in *Leurorthoceras* also dorsally. In regard to the siphuncle of the Manitoba species, however, Whiteaves states that "it would have been better to say, that its exact shape, size and relative position are not at all clearly shown in the few specimens yet collected, though it seems to have been marginal and enlarged between the septa." Judging from one of the figures accompanying Whiteaves's description of the Manitoba species, the siphuncle of the latter must have been large and different in character from *Leurorthoceras*.

In typical *Tripleuroceras*, founded by Hyatt on *Orthoceras archiaci* Barrande, from the Silurian of Bohemia, the cross-section of the conch is very similar to that of *Leurorthoceras* but the siphuncle is almost in contact with the ventral wall of the conch, its segments are distinctly nummuloidal, and the interior of the siphuncle is filled by vertical radiating plate-like deposits. Whether *Tripleuroceras robsoni* has the same type of structure remains to be determined.

In the Silurian genus *Mixosiphonoceras*, founded by Hyatt on *Cyrtoceras desolatum* Barrande, from the Silurian of Bohemia, the cross-section of the conch is triangular, but the siphuncle is situated not close to a flattened ventral side but near the unpaired angle of the triangle. Without a knowledge of the

location of the hyponomic sinus in this species it is impossible to determine with confidence whether this unpaired angle represents the ventral or the dorsal side of the conch, but in either event the siphuncle of *Mixosiphonoceras* at least appears to occupy a position directly opposite to that in the species previously discussed. Moreover, in *Mixosiphonoceras* the conch is curved lengthwise, the siphuncle being located near the concavely curved side; the segments of the siphuncle enlarge only moderately within the camerae, and the interior of the latter is occupied by vertical radiating plate-like deposits.

In the Devonian genus *Jovellania*, founded by Bayle on *Orthoceras buchi* de Verneuil, from Nehon (Manche), France, the conch is annulated and its cross-section is only slightly triangular, due to a slight flattening of the ventro-lateral sides of the conch, causing the median part of the ventral side to be slightly angulated. There is no corresponding flattening of the opposite or dorsal side of the conch. The siphuncle is located near the angulated median part of the ventral side. Where the dorso-ventral diameter is 25 mm. the center of the siphuncle is 6 mm. from the ventral angle. The segments of the siphuncle enlarge only moderately within the camerae and the interior of the latter is occupied by vertical radiating plate-like deposits.

Compared with typical *Jovellania*, *Orthoceras murrayi* is not annulated; the siphuncle is located near the strongly flattened ventral side of the conch; the form of this siphuncle is tubular instead of moniliform, and the interior of this siphuncle is not filled with radiating vertical plate-like deposits.

15. **Leurorthoceras chidleyense** Sp. nov.

Plate XXXIV, figs. 1 A, B, C, D

Lateral apical angle 11 degrees. Ventral side gently convex or distinctly flattened along its median part; dorsal side much more strongly convex. At the lower end of the specimen, where its lateral diameter is 39 mm., the radius of transverse curvature of the ventral side is 20 mm., that of the dorsal side being 28 mm. At the top of the specimen, where its lateral diameter is

52 mm., the radius of transverse curvature of the ventral side is 50 mm., that of the dorsal side being estimated at 25 mm. At this larger end of the specimen the transverse curvature at the ventro-lateral angles has a radius of about 11 or 12 mm.

Five camerae occupy a length equal to the lateral diameter of the conch at the top of the series being counted. On the dorsal side, the sutures of the septa are directly transverse. On the ventral side these sutures curve downward, producing broad shallow lobes having a depth of 4 mm. at the base of the specimen, increasing to 5 mm. at its top. The lateral curvature of these ventral lobes increases from 30 mm. at the base of the specimen to 33 mm. at its top. The septum at the base of the specimen slopes downward from the dorsal side toward the ventral side at an angle of about 82 degrees with the vertical outline of the ventral side. In fact, the structure of the phragmacone is similar to that of an ordinary species of *Orthoceras* in which one side had been filed away so as to produce a similar flattened outline.

At its passage through the septum the siphuncle has a diameter of about 3 mm. The center of the siphuncle is slightly less than one-fourth of the dorso-ventral diameter of the conch from its ventral wall. The septal necks of the siphuncle are 2 mm. in length and curve outward toward their lower margin. The connecting rings, which join successive septal necks, are preserved only on the ventral side of the siphuncle, but originally these rings appear to have enlarged to a diameter of about 6 mm. within the camerae, producing segments of the siphuncle with vertically elliptical outlines as in *Loxoceras*.

No indications of surface markings are present, the specimen being a cast of the interior of the conch.

Locality and Horizon.—From blocks found loose at Port Burwell, twenty miles west of Cape Chidley, at the northern end of Labrador. Regarded as of Black River age on account of associated fossils, also loose. Collected by A. P. Low. Numbered 7923 in the collections of the Geological Survey of Canada.

16. **Actinoceras tenuifilum** (Hall.)

Plate XXVIII, fig. 2; Plate XXXII, fig. 1

Ormoceras tenuifilum Hall, Pal. New York, 1, 1847, p. 55, pl. 15, figs. 1, *1a-c*; pl. 16, figs. 1, 1 *a-e*; pl. 17, figs. 1, 1a, b.

Type specimen.—The specimen represented by fig. 1 on plate 15 of the publication cited above is regarded as the type of the species. Its apical angle is 12 degrees. According to figure 1a on plate 16, 6 camerae occupy a length equal to the diameter of the conch at the top of the series being counted, at the smaller end of this type. The siphuncle is large. According to figure 1a on plate 15, it is submarginal in position. In reply to an inquiry regarding the vertical striae illustrated by Hall in figure 1 and again in figure 1b on plate 15, Dr. Ruedemann states in a letter:

> The surface marking on specimen figure 1 is microscopic, but very sharp and distinct. There are about 7–10 unequal striae to 1 mm. Your assumption that they belong to an interior coat is probably right, for there is a smooth patch over them at the upper end of the conch. Besides these longitudinal lines there is in one place also a system of fine transversal lines. The latter probably belong to the surface and have been projected upon the lower layer when the outer layer was dissolved.

Cotypes.—In the specimen represented by figure 1c on plate 15, the apical angle is 11 or 12 degrees. Along the smaller part of the specimen 6.5 camerae occupy a length equal to the diameter of the conch, increasing to 7 camerae toward the larger end. About 90 mm. above the smaller end, the diameter of the specimen is 46 mm., that of the siphuncle is 24 mm., and the latter is about 2 mm. from the ventral wall of the conch. The surface of the shell is smooth.

In specimen 1b on plate 16, the margin of the siphuncle is within 1 or 2 mm. of the ventral wall of the conch; 6 or 7 camerae occupy a length equal to the diameter of the conch. In specimen 1c on the same plate the siphuncle again is submarginal, and the surface of the shell is smooth. The present location of

specimen 1d is unknown. In specimen 1e the siphuncle is submarginal in position; 5 camerae occupy a length equal to the diameter of the conch at the smaller end of the specimen, increasing to 5.5 camerae at the larger end; the surface of the shell is smooth.

In specimen 1 on plate 17, the siphuncle is between 1 and 2 mm. from the ventral wall of the conch; the surface of the shell appears to have been smooth; and, judging from the curvature of the small part preserved, the dorso-ventral diameter was distinctly shorter than the lateral one. In specimen 1b, the siphuncle again is submarginal in position. In specimen 2, the type of the variety *distans*, 4 camerae occur in a length equal to the diameter of the conch at the lower end of the specimen, increasing to 5 camerae in the second fifth of the length of the specimen above its base, to 5.5 camerae near mid-length, and to 6 camerae near its top; the siphuncle is within 1 or 2 mm. from the ventral wall of the conch.

Specimens 2a and 2b on plate 58 were originally figured among Trenton species, although doubt was cast upon their occurrence in the Trenton. The matrix resembles that of typical Black River specimens from the Watertown area. Dr. Ruedemann states in a letter:

> I do not remember ever having seen an *Actinoceras tenuifilum* in the Trenton. It is quite common both in the Watertown and Leray limestones. Some specimens have been noticed in the Lowville (see Bull. 145, New York State Mus., p. 841 footnote); Dr. Ulrich claimed at the time that these should be a different species, but none were collected.

In specimen 2a mentioned above, the location of the siphuncle is submarginal, and the surface of the conch, as far as known, is smooth. In specimen 2b, the apical angle is 12 degrees. At the lower end of the specimen the diameter of the conch is 30 mm. and that of the siphuncle is 19 mm.; at the upper end, the diameter of the conch is about 51 mm. laterally, that of the siphuncle being 26 mm.; judging from the curvature of the part preserved, the shell was slightly depressed dorso-ventrally. At the bottom of the specimen 6 camerae occupy a length equal to

the diameter of the conch, increasing to 7 camerae toward the larger end of the specimen. The surface of the shell is chiefly smooth, but 2 or 3 mm. below the sutures of the septa there is in several places a transverse ridge curving downward with the sutures on the ventral side of the conch, so as to suggest the former presence of a hyponomic sinus. The amount of this downward curvature is at least 5 mm. near the larger end of the specimen. It is approximately commensurate to that of the *Actinoceras* from the Boothia Felix-King William Land area, represented in this paper by figure 2 on Plate XXX.

Figured specimen.—Figure 2 on Plate XXVIII of this paper represents a typical specimen of *Actinoceras tenuifilum* from the Black River at Watertown, New York. It is part of the duplicate material originally belonging to the New York State Museum of Natural History, and was presented to the writer by Dr. Rudolf Ruedemann. About 5 camerae occupy a length equal to the diameter of the conch at the smaller end of the specimen, increasing to 5.5 camerae at its upper end. The diameter of the siphuncle equals about 64 per cent of that of the conch, and its margin is within 1 mm. of the ventral wall of the latter. The septa are strongly concave. The septal necks descend slightly over 2 mm. below the general concave curvature of the septa, and the distance between successive annulations of the siphuncle equals or slightly exceeds 2 mm. The septa are in contact with the lower surface of these annulations. Toward the larger end of the specimen, the annulations of the siphuncle decrease in size as in *Paractinoceras*. The sutures curve downward toward the median part of the ventral side a distance of 4 or 5 mm. At the base of the siphuncle, its axial part, for a diameter of about 2 mm., is free from organic deposits, being filled with black matrix. Toward the top of the siphuncle this axial part free of organic deposits increases more or less irregularly to 5 mm. in diameter, indicating progressive deposition of organic material with increasing age.

Resume.—In typical *Actinoceras tenuifilum* the conch is slight depressed dorso-ventrally, the apical angle is about 12 degrees; the number of camerae in a length equal to the diameter of the

conch usually varies between 5.5 and 6.5, but may be as low as 4 and as high as 7. The siphuncle is relatively large, equalling at least 55 to 60 per cent of the diameter of the conch at the lower end of the latter, though apparently diminishing in size toward its upper end as in *Paractinoceras*. The sutures of the septa curve moderately downward on the ventral side of the conch. The surface of the shell usually is smooth, but occasionally is striated or ribbed transversely in a direction more or less parallel to the sutures of the septa.

17. **Actinoceras** Sp.

Plate XXX, figs. 2A, B; Plate XXXII, fig. 7

The specimen consists of a fragment of a phragmacone 130 mm. in length, of which the lower part, beneath an oblique crack, is not figured. The specimen is strongly flattened on its dorsal and ventral sides, probably due to compression of the enclosing sediments previous to solidification. In my opinion this compression of the sediments resulted merely in a shortening of their vertical dimensions, and was not accompanied by any horizontal expansion, either of the sediments or of their contents. If this view be correct, then the present lateral apical angle of the specimen and its present width correspond closely to the original lateral dimensions of the specimen, though its dorso-ventral dimensions are greatly shortened.

In its present condition the lateral apical angle of the conch equals 10 degrees, and from 6 to 6.5 camerae occupy a length equal to the lateral diameter of the conch at the top of the series of camerae being counted. Along the dorsal side of the conch the sutures of the septa curve only slightly downward, possibly only 1 or 2 mm., and even this slight downward curvature may be due to compression. Along the ventral side, on the contrary, the downward curvature of the sutures is much more pronounced, equalling 7 mm. Most of this downward curvature appears to take place along the ventro-lateral parts of the conch, the downward curvature being much more moderate along the median parts of the ventral side of the conch. At the top of the speci-

men the lateral diameter of the siphuncle appears to be 30 mm. Below the oblique crack at the base of the figured part of the specimen there is an unfigured part showing distinctly the dorsal outlines of 3 segments of the siphuncle. As far as can be determined, the width of the siphuncle here is 32 mm. where the lateral diameter of the conch is 48 mm. Unfortunately it is impossible to determine with certainty whether the location of the siphuncle is central or marginal, although I am inclined to regard it as submarginal, extending to within 1 mm. of the ventral wall ofthe conch, and with its nummuloidal segments oblique to the vertical axis. The vertical outline of the segments of the siphuncle, the distance between consecutive annulations of the siphuncle, the length and curvature of the septal necks, the adnation of the septa to the lower side of the annulations, all are similar to those of *Actinoceras tenuifilum.*

The surface of the shell is marked by low and rather broad transverse striae which tend to be sub-parallel to the sutures of the septa, especially along the broad median parts of the ventral side of the conch; but ventro-laterally, where the sutures slope more rapidly downward, the course of the transverse striae is slightly less oblique than that of the sutures. At or immediately above the sutures one of the striations tends to be slightly more conspicuous.

Locality and Horizon.—From some unknown locality, probably of Black River age, either on Boothia Felix or on King William Land. In the Palaeontologisk Museum, Kristiania, Norway. Collected by Lieut. Godfred Hansen in 1903–04.

Remarks.—The downward curvature of the sutures of the septa on the ventral side of this specimen probably is shared with all species in which the siphuncle is marginal or submarginal, though the degree and angularity of this downward deflection may vary in different species. It is regarded as related more nearly to *Actinoceras tenuifilum* than to any other described species, but a better knowledge of the siphuncle is needed in order to determine its relationship with some degree of confidence. It may be a new species but in the absence of definite knowledge of its siphuncle it can not serve as a type.

18. **Actinoceras amundseni** Sp. nov.

Plate XXIX, figs. 1A, 1B; Plate XXXII, fig. 3

Specimen exposing the ventral side of the cast of the interior of the phragmacone, including the sutures of the septa, and exhibiting also the dorsal side of the siphuncle.

The diameter of the conch, as far as can be determined from the transverse curvature of its ventral side, is estimated at 70 mm. Apparently there is a slight tendency toward angularity along the median part of this ventral side. It is estimated that 6 camerae occupy a length equal to the diameter of the conch. The sutures curve strongly downward on its ventral side, forming an angular ventral lobe or hyponomic sinus with sides diverging at an angle of 140 degrees. The septa are deeply concave.

The siphuncle is almost in contact with the ventral wall of the conch, being 1 or 2 mm. distant from the latter. The maximum diameter of the segments of the siphuncle is 28 mm., narrowing to 19 mm. at the grooves separating the segments. Where the height of the segments is 13 mm., the septa are adnate to the lower part of these segments for a height of 5 mm.; along this part of the segments the vertical outline of the latter is nearly straight or only faintly concave. Above the point of departure of the septa, the vertical outline of the segments is strongly convex, reaching its maximum 7 or 8 mm. above the base of the segments. The upper surface of the segments forms an angle of 105 or 110 degrees with the vertical axis of the conch, rising toward its ventral side. No trace of surface markings remains.

Locality and Horizon.—From some unknown locality, probably of Black River age, either on Boothia Felix or on Prince William Land. In the Palaeontologisk Museum, Kristiania. Collected in 1903–04 by Lieut. Godfred Hansen, on the expedition of the Gjoa, led by Captain Roald Amundsen, in whose honor this species is named.

Remarks.—In *Actinoceras amundseni* slightly more than 2 segments of the siphuncle occur in a length equal to the maximum diameter of these segments. This is true also of *Huronia*

obliqua Stokes; in the type of *Huronia septata* Parks this number is exactly 2. The chief difference between *Huronia septata* and *Huronia obliqua* noted so far consists in the distinct obliquity of the upper surface of the segments of the siphuncle in the latter and in the almost directly transverse slope of this surface in the former species; thus indicating that the siphuncle of *Huronia obliqua* is strongly excentric in position while that of *Huronia septata* is nearly central. In this respect *Actinoceras amundseni* resembles *Huronia obliqua* more closely. However, in *Actinoceras amundseni* the tendency toward a concave lateral outline along the lower half of the segments of the siphuncle is much less conspicuous, and this difference is regarded as sufficient to indicate a new species. The rather angular downward deflection of the sutures of the septa along the median line of the ventral side of the conch may be another distinctive feature, although it is shared with *Actinoceras imbricatum* Hisinger, and I suspect that it is present also in other species in which the siphuncle is virtually in contact with the ventral wall of the conch.

To me the general aspect of *Actinoceras amundseni* and of *Huronia septata* is Silurian rather than Ordovician, but lithologically the type of *Actinoceras amundseni* resembles other specimens from the Boothia Felix-King William Land area regarded as of Black River age, and the type of *Huronia septata* was obtained at the Lower Rapids of the Shamattawa River, where the general assemblage of fossils is Ordovician.

The type of the genus *Huronia* is *Huronia bigsbyi* Stokes. In this species the segments of the siphuncle resemble short inverted pestles, the lower two-thirds of each segment being nearly cylindrical, the upper third enlarging more or less abruptly. *Huronia vertebralis* Stokes and *Huronia minuens* Barrande have the same types of structure. In *Huronia obliqua* Stokes, *Huronia turbinata* Stokes, and *Huronia distincta* Barrande the lower part of the segments of the siphuncle is turbinate rather than cylindrical. The figure of *Huronia portlocki* Stokes resembles that of an *Actinoceras* in which the septa are adnate to the lower face of the annular segments of the siphuncle. *Orthoceras persiphonatum* Billings also appears to be an *Actino-*

ceras. An examination of the types will be necessary to determine the relationship of these so-called *Huroniae*.

In typical *Huronia*, the septa are adnate to the lower part of the successive segments of the siphuncle, from the base of the cylindrical part of each segment up to the outer margin of the lower face of the annular enlargement at its top. *Huronia*, therefore, differs from *Actinoceras* only in the cylindrical elongation of that part of each segment of the siphuncle which lies beneath the annulation.

19. **Actinoceras** Sp.

Plate XXVII, fig. 7; Plate XXXII, fig. 2

Actinoceras sp. Holtedahl. On Some Ordovician Fossils from Boothia Felix and King William Land collected during the Expedition of the Gjoa. Videnskapsselskapets Skrifter, I, Matnaturv. Klasse, 1912, No. 9, pl. III, fig. 2.

Figured specimen.—The specimen consists of the ventral side of a phragmacone. Owing to weathering. the siphuncle and the adjacent parts of the septa are exposed. Near the base of the specimen the segments of the siphuncle have a maximum diameter of 20 mm.; the same diameter is shown 100 mm. farther up, at the top of the specimen. The diameter of the conch at the upper end of the specimen is estimated at 60 to 65 mm. If this be correct then the diameter of the siphuncle is about one-third of that of the conch. The apical angle of the specimen is supposed to have been relatively small, possibly 5 degrees, but the evidence for such an apical angle is not satisfactory. The location of the siphuncle is strongly excentric. This is indicated by the slope of its segments, the latter forming an angle of about 60 degrees with the vertical axis of the siphuncle. In fact, the siphuncle probably was almost in contact with the ventral wall of the conch.

About 9 camerae occupy a length equal to the estimated diameter of the conch. Nothing is known about the exact direction of the sutures of the septa, but in other species with marginal siphuncles these sutures usually curve more or less strongly

downward on the ventral side of the conch. Where the diameter of the conch is 60 mm. the depth of concavity of the septa equals at least 16 mm. The segments of the siphuncle are strongly nummuloidal, contracting from a maximum diameter of 19 mm. to one of 14 mm at the lower margin of the septal necks. The latter are short, less than 1 mm. in length, the distance between successive segments of the siphuncle equalling scarcely 1 mm.

The central part of the siphuncle is occupied by a thick strand of calcareous deposits enlarging toward the top; from this central strand deposits radiate toward the upper part of the segments of the siphuncle. The strand itself consists of radiating elements 2 or 3 mm. wide, transversely concave when viewed from beneath, sometimes weathering so as to present an appearance slightly like that of a *Cystiphyllum*.

Locality and Horizon.—From some unknown locality, probably of Black River age, either on Boothia Felix or on King William Land. In the Palaeontologisk Museum, Kristiania, Norway. Collected by Lieut. Godfred Hansen in 1903–04.

Remarks.—In the structure of its siphuncle this species resembles *Actinoceras tenuifilum* from the Black River limestone at Watertown, New York. It differs in having relatively more numerous camerae and the size of the siphuncle appears to be relatively much smaller. It probably is a new species but not sufficiently well preserved to serve as a type.

20. **Actinoceras** Sp.

Plate XXIX, fig. 2

The specimen consists of a vertical dorso-ventral section of the phragmacone formed during the breakage of the rock. This section exposes the walls of the conch, the septa, and the hollow spaces formerly occupied by the nummuloidal segments of the siphuncle.

The apical angle of the specimen in a dorso-ventral direction is 9 degrees. The number of camerae in a length equal to the dorso-ventral diameter of the conch varies from 3 at the base

of the specimen, where the diameter of the conch is 23 mm., to 4 at its top where the diameter of the latter is 33 mm. The diameter of the siphuncle at these points is 15 and 21 mm. respectively. The siphuncle either is in actual contact with the ventral wall of the conch or is scarcely more than 1 mm. distant from the latter. The inner part of the groove separating successive nummuloidal segments of the siphuncle is so narrow and angular that the septal necks must have been short, possibly less than 1 mm. The septa are in contact with the lower side of the segments of the siphuncle. The nummuloidal segments incline at an angle of about 75 degrees with the vertical axis of the conch.

Locality and Horizon.—From some unknown locality, probably of Black River age, either on Boothia Felix or on King William Land. In the Palaeontologisk Museum, Kristiania, Norway. Collected by Lieut. Godfred Hansen in 1903–04.

Remarks.—This species is characterized by its relatively large siphuncle and the relatively small number of camerae. In both of these respects, especially in the height of the camerae. it differs from *Actinoceras bigsbyi* Bronn, and it probably is a new species.

The specimen figured by Holtedahl from the Boothia Felix—King William Land area as *Actinoceras beloitense* Whitfield (Holtedahl, pl. IV, fig. 2) differs from all other forms here figured in its small siphuncle traversing relatively tall camerae. The number of annulations of the siphuncle in a length equal to its diameter is only two apparently.

21. **Actinoceras tenuifilum centrale** Var. nov.

Plate XXVIII, fig. 1; Plate XXXII, fig. 4

Apical angle about 10 degrees; cross-section circular. Seven and a half camerae occupy a length equal to the diameter of the conch at the top of the series being counted. The sutures are almost directly transverse. The siphuncle is practically central in position, its distance fron the ventral wall being 2 mm. less than its distance from the dorsal wall of the conch. Its diameter

equals 57 per cent of that of the conch. The curvature of the septa if continued to the center would cause a maximum concavity of 5 mm. where the diameter of the conch is 46 mm., and the segments of the siphuncle at this point contract from a maximum width of 26 mm. at the annulations to scarcely 19 mm. at the inner margin of the septal necks. The septa are adnate to the lower surface of the siphuncular annulations, becoming free from the latter along a circle 23 mm. in diameter. The septal necks curve downward for a distance of slightly more than one millimeter below the general curvature of the septae. The connecting rings that extend from the base of one septal neck to the septum next beneath form the annulations of the siphuncle, and in vertical sections they present strongly convex outlines laterally, while their upper surface curves strongly inward or even slightly downward on approaching the base of the septal necks. The vertical distance between consecutive siphuncular annulations is from one-fifth to one-fourth of the height of the camerae.

The surface of the conch is smooth or obscurely striated transversely with a tendency toward a slight groove at the sutures of the septa.

Locality and Horizon.—From Watertown, New York; occuring in the Black River limestone. Specimen from duplicate material in the New York State Museum of Natural History, at Albany, New York; presented by Dr. Rudolf Ruedemann.

Remarks.—*Actinoceras tenuifilum centrale* is distinguished from typical representatives of the species by the central position of its siphuncle; the camerae are relatively more numerous, producing a different outline in the segments of the siphuncle; at the same width of the conch, these segments do not diminish in size conspicuoulsy toward the upper part of the conch. Additional specimens may prove this form to belong to a distinct species.

22. **Actinoceras** cf. **tenuifilum centrale**

Plate XXVIII, fig. 4; Plate XXXII, fig. 5

Specimens cut vertically through the center of the siphuncle, and polished to show the structure of the interior of the conch. The opposite part of the specimen ends abruptly within the matrix along a vertical plane passing along the most distant margin of the siphuncle in a direction parallel to the polished section, as though part of the specimen had weathered away before fossilization. The apical angle of the conch is estimated at 7 degrees. At the base of the specimen the width of the conch is 48 mm.; 8 camerae occupy a length equal to the diameter of the conch at the top of the series being counted. The septa are moderately concave, the amount of concavity equalling 10 mm. in a width of 48 mm. at the base of the specimen. At this point the maximum diameter of the segments of the siphuncle equals 23 mm., diminishing to 17.5 mm. at the lower margin of the septal necks. The siphuncle is moderately excentric in position; as far as may be determined from the specimen at hand, its distance from the ventral wall at the base of the specimen is about 9 mm., compared with a distance of 15 mm. from the dorsal wall. The septal necks descend about 1 mm. below the general curvature of the septa, the intervals between successive segments of the siphuncle equalling about 1.5 mm.

Locality and Horizon.—From some unknown locality, probably of Black River age, either on Boothia Felix or on King William Land. Collected in 1903–04 by Lieut. Godfred Hansen. In the Palaeontologisk Museum, Kristiania, Norway.

Remarks.—Compared with either *Actinoceras tenuifilum centrale* or the variety *ursinum* the siphuncle of the specimen here described is relatively smaller. It is impossible to determine whether the siphuncle actually becomes narrower toward the top, as in *Paractinoceras*, or whether the appearance of narrowing in this direction is due to the section having been cut more or less oblique to the vertical axis. In the relative number of camerae this specimen approaches the variety *ursinum*. It probably is a distinct variety, but the specimen is inadequate for more exact discrimination.

23. **Actinoceras tenuifilum ursinum** Var. nov.

Plate XXVIII, fig. 3; Plate XXXII, fig. 6

Actinoceras Bigsbyi (-A. tenuifilum ?) Holtedahl, Paleozoic Series of Bear Island, 1919, p. 131, pl. 13, fig. 5.

Apical angle 16 degrees. Siphuncle apparently nearly central, its diameter varying from 65 per cent of that of the conch at the base of the specimen to 57 per cent at its top. From 9 to 9.5 camerae occupy a length equal to the diameter of the conch at the top of the series being counted. The structure of the annular segments of the siphuncle and the degree of concavity of the septa closely resembles that of *Actinoceras tenuifilum centrale*, from the Black River limestone of Watertown, New York. The chief differences consist in the relatively greater number of camerae and in the greater apical angle of the conch.

Locality and Horizon.—From the western part of the Antarctic Mountain area on Bear Island. In the *Tetradium* limestone member of the Heclahook System, regarded as of Black River age. Original of figure 5 on plate 13 in the publication cited above. In the Palaeontologisk Museum, Kristiania, Norway. Collected by Holtedahl in August, 1918.

Remarks.—The species later named *Actinoceras Bigsbyi* by Bronn was first figured and described by Bigsby from the equivalent of the Black River limestone on Thessalon Island in the northwestern corner of Lake Huron. Bronn's first figure (Leth. Geog., 1, 1837, p. 98, Plate I, fig. 8) is a reproduction of Bigsby's figure 1 on plate 25 of the Trans. Geol. Soc. London, 1, 1824, p. 198, in which, according to Foord, the segments of the siphuncle are not oblique to the long axis of the siphuncle (Foord, Catalogue of Fossil Cephalopoda, 1888, p. 170). Bronn's second figure, published on his plate 1′, is that of a species having oblique segments of the siphuncle, the latter being in contact with the ventral wall of the conch. Since Bronn's first figure must be regarded as the type, it would be desirable to know how closely it resembles the form here described as *Actinoceras tenuifilum centrale*. As far as can be judged from the figure presented by Bigsby, *Actinoceras bigsbyi* has an apical angle of

only 8 degrees, about 6.5 camerae occupy a length equal to the diameter of the conch, and the diameter of the siphuncle is about half of that of the conch.

Under these conditions, *Actinoceras tenuifilum* is not considered as identical with *Actinoceras bigsbyi* nor with the Bear Island species here under consideration. How close the relationship of the Bear Island species is to *Actinoceras bigsbyi* can not be determined until a more exact knowledge of the type of the latter has been obtained. Judging from the greater apical angle of the Bear Island form, its more numerous camerae, and its relatively wider siphuncle, there is a probability of its proving distinct from typical *Actinoceras bigsbyi*. Its resemblance to *Actinoceras tenuifilum centrale* is greater, but even in this case differences may be noted and additional material will be required to determine the degree of relationship.

24. **Actinoceras parksi** Sp. nov.

Plate XXXV, fig. 3

Actinoceras bigsbyi Parks, Trans. Royal Canadian Inst., 11, 1915, p. 23, pl. 6, fig. 7.

Type.—Specimen a fragment 140 mm. in length, consisting of one side of the phragmacone, exposing both the outer wall of the conch and the wall of the siphuncle. The conch enlarges at a rate of 18 mm. in a length of 100 mm. in a lateral direction, indicating an apical angle of 10° in that direction. The conch apparently is depressed in a dorso-ventral direction, but the depression appears to consist chiefly in a flattening of the median part of the ventral side. If this flattening is not due in part to compression during fossilization, then it must have formed a conspicuous feature of the original complete specimen. Possibly the dimensions at the larger end of the specimen were 68 mm. in a lateral direction and 52 mm. in a dorso-ventral one. At the smaller end of the specimen the corresponding dimensions appear to have been 48 and 44 mm. The rapid increase in the amount of flattening of the ventral side toward the upper end of this specimen appears to be too great to be normal, thus

suggesting that at least part of the flattening may be due to compression during fossilization.

The sutures of the septa apparently incline from the dorsal toward the ventral side of the conch at an angle of about 75° with the dorsal side of the conch, which suggests an angle of about 85° with the ventral side; however, the rate of inclination is only an estimate. The location of the siphuncle is 22 mm. from the dorsal wall at the top of the specimen, where the lateral diameter is 68 mm.; on the ventral side the siphuncle probably was in contact with the ventral wall of the conch, and even may have suffered a certain amount of flattening there. At the top of the specimen the lateral diameter of the siphuncle is estimated at 43 mm.; at its base it probably was 33 or 34 mm., indicating an increase in width of 10 or 11 mm. in a length of 125 mm., or an apical angle of about 5 degrees. In a length equal to the lateral diameter of the conch there are 6 camerae; in a length equal to the lateral diameter of the siphuncle there are about 4 camerae or at least nearly that number.

At the top of the specimen, where the vertical distance between the septa along the siphuncle is 10 mm., the short tubular necks of the septa extend downward 4.5 mm., the connecting rings joining successive septal necks having a vertical lengths of 5.5 mm. These connecting rings or annulations extend abruptly outward beyond the tubular septal necks for distances of 4.5 mm. The septa practically are in contact with the lower surface of the annular segments of the siphuncle for a distance of 4 mm. from the upper margin of the septal necks. Along this part of their course they form an angle of about 60° with the dorsal side of the siphuncle, rising 17 mm. in passing from the upper margin of the septal necks to the dorsal wall of the conch.

Calcareous deposits fill the interior of the annulations along the lower part of the specimen, but along the upper part of the latter the distal part of the annulations is occupied only by the same sort of matrix which has filtered also into the camerae, indicating that it was unoccupied at the time of the death of the animal. From the interiors of these annulations the calcareous deposits extend nearly horizontally inward for 3 or 4 mm. toward the interior of the siphuncle.

The surface of the conch apparently was smooth.

Locality and Horizon.—From the Lower Rapids on the Shamattawa River, in northern Manitoba. In the Ordovician.

No. 308S, in the Royal Ontario Museum of Paleontology at Toronto.

Remarks.—This species is characterized by the relatively long tubular septal necks separating the relatively narrow, abruptly projecting annulations.

25. **Cyclendoceras annulatum** (Hall)

Plate XXXI, fig. 3

Endoceras annulatum Hall, Pal. New York, 1, 1847, p. 207, pl. 44, figs. la, lb. Cyclendoceras annulatum Grabau and Shimer, N. Am. Index Fossils, 2, 1910, p. 43, fig. 1241.

Type specimen.—Phragmacone 225 mm. in length, retaining 26 camerae in a length of 22 mm.; of these the lower 5 occupy at length of 38 mm. and the upper 5 a length of 42 mm. Since only 16 transverse annulations occur in this length of 26 camerae it is evident that the rhythmic enlargement of the aperture of the shell at the annulations has no connection with the periodic withdrawal of the lower part of the animal from contact with the basal part of the living chamber. The specimen enlarges from a diameter of 59 mm. at its base to 70 mm. at a point 185 mm. farther up, or at the rate of 6 mm. in a length of 100 mm., thus indicating an apical angle of 3.5 degrees. About 7 camerae occur in a length equal to the diameter of the conch. The cross-section of the conch is nearly circular.

The sutures of the septa are directly transverse or only slightly lower on the ventral side. The concavity of the septa is about one-fifth of the diameter of the conch. On the ventral side of the conch the vertical sections of the septa have straight courses from the wall of the conch to within 3 mm. of the siphuncle. On the dorsal side the concave curvature of the septa, from the wall of the conch, to within 3 mm. of the siphuncle, only slightly exceeds 1 mm. Beginning 3 mm. from the siphuncle, the inner parts of the septa curve strongly downward, coming in contact with

the lower part of the funnel of the septum beneath at a point about 4 or 5 mm. below the general concave curvature of this lower septum. The septal funnels contract slightly about 2 mm. before reaching contact with the funnels next beneath, and continue downward to a point slightly more than half the length of the second camera beneath the septum at which the funnel originates. The diameter of the siphuncle is one-third of that of the conch, and its ventral side is distant one-fifth of the diameter of the conch from the ventral wall.

The annulations of the conch are low and broad, rising only 1 mm. above the intermediate grooves. They cross the conch obliquely, descending from the dorsal toward the ventral side a distance slightly exceeding the height of one camera, at an angle of about 12 degrees with a horizontal line. The interior of the siphuncle of the type exposes only a single endocone having a length between 100 and 110 mm.

Locality and Horizon.—From the Trenton limestone at Middleville, New York. Type, numbered 811, in the American Museum of Natural History in New York city.

Remarks.—*Cyclendoceras annulatum* probably is confined to the typical Trenton of New York and of the immediately adjacent states. Similar species occur in approximately similar horizons in adjoining geological provinces. The species described and figured by Whiteaves (Trans. Royal Soc. Canada, 9, 1891, p. 77, pl. 5, figs. 1, 1a) from the Trenton (Black River ?) between the second and third rapids of the Nelson River, west of Hudson Bay, enlarges much less rapidly and has much more oblique annulations. It is a distinct species.

In typical *Cyclendoceras* the annulations usually are distinctly more prominent on the ventral than on the dorsal side of the conch. The sutures of the septa curve slightly downward both on the ventral and on the dorsal side. The most striking feature usually is the strong downward curvature of the annulations along the ventro-lateral sides of the conch, and their relatively broad concave curvature across the ventral side. Across the dorsal side of the conch their course may be nearly straight or slightly curved either in an upward or in a downward direction.

Annulated *Endoceratidae*, such as here are included in *Cyclendoceras*, are very well known in northern faunas. At least a dozen species have been studied. They occur in loose Black River blocks west of Cape Chidley at the northern end of Labrador, on the Nelson and Shamattawa rivers west of Hudson Bay, in Manitoba, and along that Arctic invasion which extended southwestward to the Black Hills of South Dakota, the Big Horn Mountains of Wyoming, the Teton range of Idaho, and the Canyon City area of Colorado. At least 6 species are known from this southwestern extension of the Arctic invasion. Two species occur in Wisconsin, and 2 occur in the Watertown area of New York, one of which, *Cyclendoceras annulatum*, a Trenton form, is the genotype.

26. **Cyclendoceras or Dawsonoceras** sp.

Plate XXXI, fig. 2

Endoceras (Cyclendoceras) annulatum Hall, On Some Ordovician Fossils from Boothia Felix and King William Land, collected during the Expedition of the Gjoa. Videnskapssilkapets Skriften, 1912. Pl. IV, fig. 1.

A. Specimen figured by Holtedahl.—Diameter at lowest well preserved annulation, 57 mm. Rate of enlargement of conch, 3 degrees or less. Compressed, partly subsequent to death, the shorter diameter equalling about 77 per cent of the longer one. Five camerae occur in a length equal to the longer diameter of the conch, each camera being occupied by a transverse annulation whose crest is located slightly above mid-height of the camera. The sutures rise gently toward a point which is slightly toward the left of the median line of the published figure. Toward the right of this point, both sutures and annulations are almost directly transverse. Toward the left, both sutures and annulations curve downward, but much more moderately than in typical *Cyclendoceras*.

B. Specimen figured in this Bulletin (Plate XXXI, fig. 2).—Seven annulations occur in a length equal to the diameter of the conch. These annulations rise 1.5 mm. above the intervening grooves.

Their crests are broadly rounded and are approximately of the same width as the intervening grooves. The annulations rise toward a point which is slightly toward the left of the median line of the figure here published.

In the moderate curvature of the annulations, both specimens resemble *Dawsonoceras* rather than *Cyclendoceras*. In addition to the two specimens described above, a third one was sent by Dr. Holtedahl. Two of them apparently present faint traces of vertical ribs, but not sufficiently distinct to give confidence to their determination as *Dawsonoceras*. In the absence of any knowledge of their siphuncles, their apparent association with Ordovician forms favors their reference to *Cyclendoceras*.

Locality and Horizon.—From some unknown locality on Boothia Felix or King William Land. Collected in 1903–04 by the Gjoa expedition. Deposited in the Palaeontologisk Museum, at Kristiania. From the Silurian, in strata equivalent to the Niagaran or Guelph.

27. **Eurystomites (?) boreale** Foord

Plate XXXIII, figs. 9 A, C

Trochoceras boreale Foord, Catalogue of Fossil Cephalopoda in the British Museum of Natural History, pt. II, 1891, p. 23.

Original description.—"*Sp. Char.* Shell discoid, compressed, whorls in contact, about three in number, all exposed. Section elliptical, the ratio of the two diameters about as 6: 8; siphuncle between the centre and the convex side. Septa approximate; two lines apart on the sides, where the shell has a diameter of 11 lines, increasing to $2\frac{1}{2}$ lines where the diameter is $1\frac{1}{2}$ inches. Body-chamber and test unknown. There are no indications of ribbing or of any ornaments upon the cast.

"*Remarks.* This is a much larger species than any of those of the Niagara rocks of North America that come at all near to it. *Trochoceras Aeneas*, Hall, agrees with it in the distance of the septa and position of the siphuncle, but the section is different, and there are marks of very distinct annulations upon the cast. Salter (Journal of a Voyage in Baffin's Bay and Barrow Straits in the years 1850–1851, by Dr. P. C. Sutherland (1852), Appendix, p. ccxxii) described, amongst

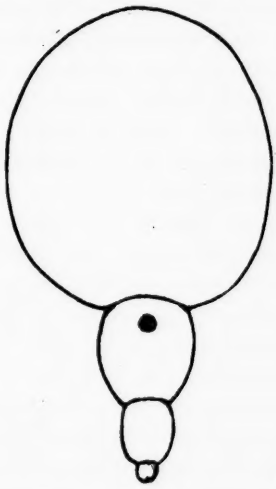
other Arctic Silurian fossils, one which he called "Lituites—, n. sp.;" but this is stated to have six or seven whorls at least, and therfore it could have no affinity with the present species. There was, therefore, no other course but to give this form a new name.

"*Horizon.* Silurian.

"*Locality.* Wellington Channel, Arctic America.

"Represented in the Collection by one example, collected by Captain Inglefield."

The specimen described above is numbered 96955 in the British Museum. Dr. F. A. Bather has kindly presented me with an excellent cast of the type, also a photograph, and a cross-section. Both the cast and the photograph suggest that the color of the matrix is black. The cross-section is accompanied by the following annotations, evidently applicable to that whorl which exposes the siphuncle: Siphuncle circular, diameter 2.2 mm.; distance from venter, 2.8 mm.; dorso-ventral diameter of whorl, 15.7 mm.; lateral diameter 13.8 mm.



EURYSTOMITES (?) BOREALE (FOORD). CROSS-SECTION OF TYPE, SHOWING LOCATION OF SIPHUNCLE. DRAWN BY DR. F. A. BATHER

From this cross-section it is evident that the conch is a nautilicone with a distinctly impressed dorsal side. Since no reference

is made to enlargement of the segments of the siphuncle within the camerae, these segments may be regarded as cylindrical in form. From the cast it appeared possible to secure a transverse section of the whorl (at the point B in fig. 9A on Plate XXXIII of this paper) which is angularly elliptical (as in fig. 9B of the plate just cited), but the excellent cross-section presented by Dr. Bather removes all doubt about the outline of the whorls. Laterally, the sutures of the septa are gently concave when viewed from above, but nothing is known of their direction along the ventral side of the conch.

I do not know of any Silurian nautiloid combining the characteristics here noted. Among Ordovician forms the cast of the interior of the some species of *Plectoceras* present a somewhat similar appearance on lateral view. However, the Wellington channel specimen is not known to have its sutures curving distinctly downward, along the *ventral* side of the conch, as in typical *Plectoceras*. The absence of any indication of obliquely transverse plications on the ventro-lateral sides of the specimen is not sufficient to exclude it from *Plectoceras*, since casts of the interior of some species of this genus do not show readily recognizable undulations, even when these are quite boldly marked on the exterior. The shell of typical *Plectoceras* is so thick that the interior may be quite smooth even in the presence of a strongly ribbed exterior.

I do not know of any Silurian species of *Plectoceras*. *Plectoceras jason* and *Plectoceras tyrans* were described by Billings from the Chazyan of the Mingan Islands, in northeastern Canada. *Plectoceras bondi* was described by Safford from the Stones River of central Tennessee. *Plectoceras undatum* described by Conrad from the Black River at Watertown, New York. *Plectoceras occidentale* was described by Hall from the Platteville of Wisconsin. *Plectoceras halli* was described by Foord from the Black River near Quebec, in Canada. The Wellington Channel species described by Foord under *Trochoceras boreale* may not belong to *Plectoceras*. Its affinities may be with *Eurystomites*, in which the shell is not conspicuously costated. This would place it among the *Tarphyceratidae*.

28. **Orthoceras** Sp.

Plate XXXIV, fig. 3 A, B

On the Fossil Faunas from Per Schei's Series B in Southwestern Ellesmereland, Rep. Second Norwegian Arctic Expedition, in the "Fram" 1898–1902, No. 32, 1914, p. 32.

Fragment 15 mm. long, consisting of a single camera 3.5 mm. in length, surmounted by the lower part of a living chamber 17 mm. in length. No trace of the aperture is present, so that the original length of the living chamber can not be determined. Moreover, the single camera present is so long that the conch probably is immature, so that the size of a mature specimen also remains unknown. The suture of the septum inclines at an angle of about 75 degrees with the vertical axis of the conch from the dorsal toward the ventral side of the conch. This suture is almost straight, with a slight tendency toward horizontality along the middle of the lateral sides. The cross-section of the conch is transversely elliptical. The lateral diameter being 14 mm., and the dorso-ventral one slightly over 11 mm. The ventral side is distinctly more flattened than the dorsal one. The septum is quite evenly concave, the depth of the concavity being 2.5 mm. At its passage through the septum the siphuncle is 2.3 mm. in diameter; its center is 6 mm. from the dorsal margin of the septum and an equal distance from the ventral margin, but, measured in a direction strictly transverse to the vertical axis of the conch, it is 5 mm. from the dorsal side of the latter and 6 mm. from its ventral side, thus being slightly dorsad of the center of the conch. A vertical section through the center of the camera failed to reveal any trace of the siphuncle except at its passage through the septa. The septal neck apparently was confined to a slight downward inflection of the septum. The surface of the shell appears to be smooth.

Locality and Horizon.—Valley south of Borgen in Goose Fjord, in southwest corner of Ellesmereland. From the fragmental limestone in the upper part of series B of Per Schei. Collected by Per Schei June 28, 1902, and deposited in the Paleontological Collections of Kristiania University.

Remarks.—Attached to the upper part of the specimen are a brachial valve of *Camarotoechia litchfieldensis angustata* Holtedahl and a pedicel valve of *Spirifer vanuxemi prognostica* Schuchert, the only two brachiopods known so far from this fragmental limestone horizon. Unknown species of *Fistulipora* and *Fenestella* complete our present knowledge of the fauna from this horizon, which is correlated by Holtedahl with the Keyser member of the Helderbergian.

PLATE XXVII

Fig. 1. Cf. *Euconia quebecensis* Billings. The more apical part of the specimen consists of a vertical section passing through the center of the umbilicus. At the base, parts of the two lower whorls are exposed along oblique surfaces. From Victoria Head on Bache Peninsula, Ellesmereland; in the *Orthoceras* limestone, regarded as of Canadian age. In the Paleaontologisk Museum, Kristiania; collected by Per Schei in 1899. Size 22/10.

Fig. 2. *Clarkoceras holtedahli* Sp. nov. *A*, an obliquely lateral view; a rectangular section has been cut out from the right half of the ventral side of the conch; one side of this section is parallel to the dorso-ventral diameter, the other side is at right angles to the first; the former exposes the siphuncle, and the second shows the strong lateral concave curvature of the septa. *B*, a strictly lateral view of the same specimen, with an attempt to indicate the probable dorsal and ventral outlines of the conch. Figure 1 on Plate 33 is a cross-section of this specimen, made at the seventh septum above its base. From Victoria Head on Bache Peninsula, Ellesmereland; in the *Orthoceras* limestone, regarded as of Canadian age. In the Palaeontologisk Museum, Kristiania; collected by Per Schei in 1899.

Fig. 3. *Ellesmeroceras scheii* Gen. et Sp. Nov. *A*, ventral view, showing rise of sutures toward the siphuncle; size 22/10. *B*, the same view, but of natural size. *C*, lateral view, with siphuncle on extreme right of figure; along the left side of figure the sutures are not preserved. Figure 3 on Plate 33 is a cross-section of the conch taken at the top of the phragmacone, the position and size of the siphuncle being inferred from the actual exposure of this siphuncle at the base of the specimen. From Victoria Head, on Bache Peninsula, Ellesmereland; in the *Orthoceras* limestone, regarded as of Canadian age. In the Palaeontologisk Museum, Kristiania; collected by Per Schei in 1899.

Fig. 4. Cf. *Cameroceras tenuiseptum* (Hall). *A*, lateral view, with septa not preserved on left side; sutures of septa apparently form shallow lobes. *B*, another view, oriented so as to show the right side of figure 4*A*; the irregularities in the course of the septa are due to irregular weathering of the surface of the specimen. *C*, basal view of same specimen, showing cross-section of specimen in its present condition, no definite knowledge regarding the siphuncle is presented. Generic reference uncertain. From Victoria Head, on Bache Peninsula, Ellesmereland; in the *Orthoceras* limestone, regarded as of Canadian age. In the Palaeontologisk Museum; Kristania; collected by Per Schei in 1899.

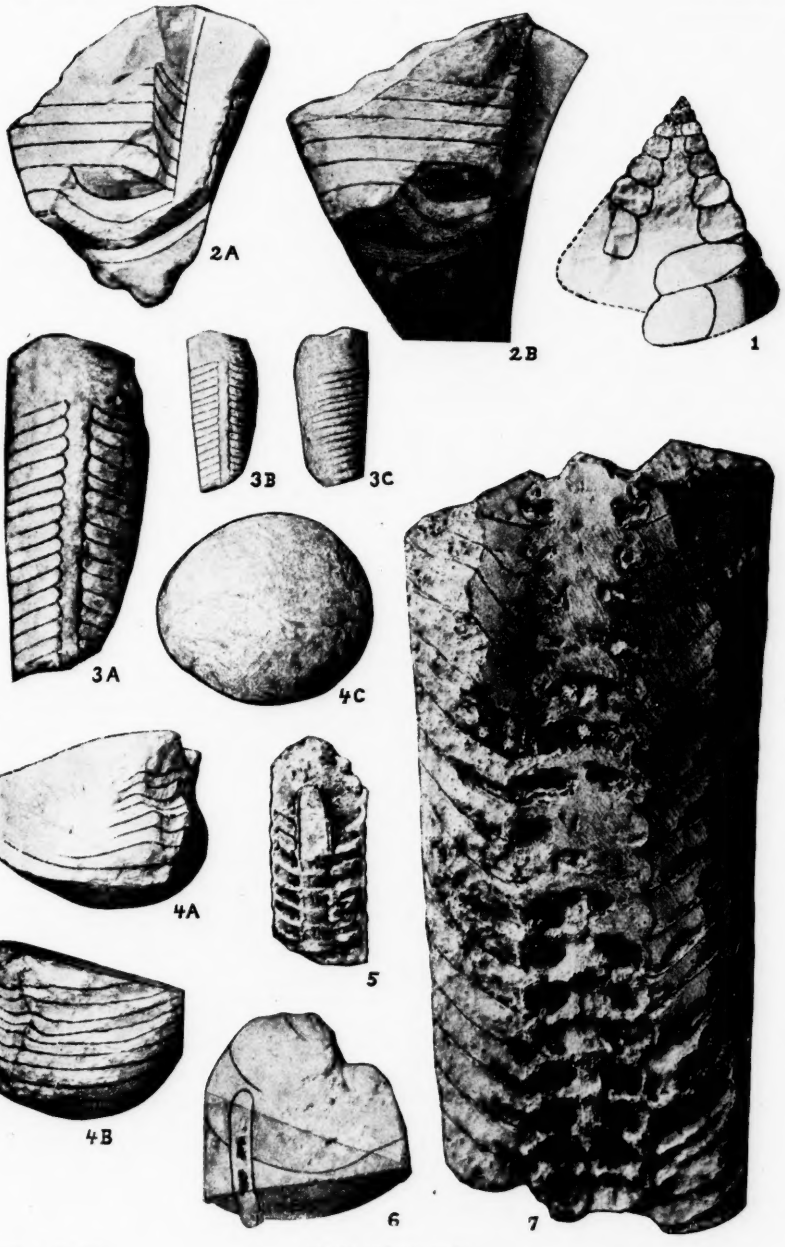


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Fig. 5. *Protocycloceras* cf. *lamarcki* (Billings). A natural vertical section exposing the siphuncle, apparently with invaginating septal necks. Figures 5*A* and 5*B* on Plate 33 represent a cross-section and a vertical section of this specimen, as far as can be determined from the part preserved. From Bear Island; in the younger dolomite division of the Heclahook system, regarded as of Canadian age. In the Palaeontologisk Museum, Kristiania; collected by Dr. Olaf Holtedahl in July, 1918. Original of fig. 1 on Plate XIII on Holtedahl's paper "On the Paleozoic Series of Bear Island," 1919.

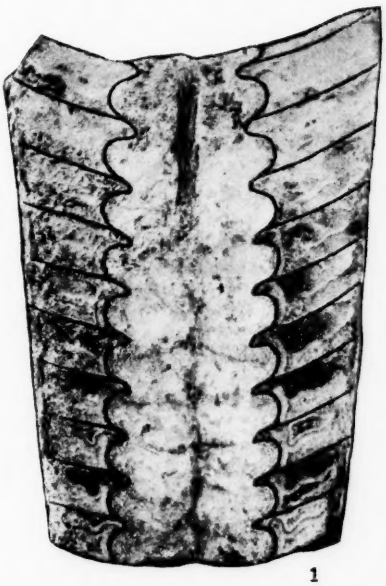
Fig. 6. *Deltoceras* (?) sp. A section lengthwise through the siphuncle and parallel to the dorso-ventral diameter, exposing the outline of the septa; triangularly limited by two oblique sections, of which the lower one is margined by a second septum, while the upper oblique section exposes only the ventral part of a third septum. Figures 6*A* and 6*B* Plate 33 represent the same specimen, the first in its present condition, the second with an attempt at restoration, the missing parts being indicated by dotted lines. Figure 6*C* on the same plate is a cross-section of the specimen. From Bear Island; in the younger dolomite series of the Heclahook system, regarded as of Canadian age. In the Palaeontologisk Museum, Kristiania; collected by Dr. Olaf Holtedahl in July, 1918. Figure 2 on Plate XIII of Holtedahl's paper "On the Paleozoic Series of Bear Island," is a direct view of the septum at the base of the specimen, before this specimen was sectioned.

Fig. 7. *Actinoceras* sp. A vertical section passing in a lateral direction through the siphuncle; along the lower half of the specimen the exposure is due to weathering, along its upper half the weathered surface has been ground off sufficiently to expose the outlines of the annulations of the siphuncle. Along the center of the siphuncle is the heavy strand-like deposit characteristic of numerous species of *Actinoceras*. Figure 2 on Plate 32 is an attempt at a cross-section of this specimen, suggesting that its siphuncle was small compared with the diameter of the conch. From some unknown locality either on Boothia Felix or on King William Land; probably from the Black River limestone. In the Palaeontologisk Museum, Kristiania; collected by Lieut. Godfred Hansen in 1903–04. Original of Fig. 2 on Plate III of Holtedahl's paper "On Some Ordovician Fossils from Boothia Felix and King William Land," 1912, however, since the publication of Holtedahl's paper the matrix has been ground away from the left side of the specimen in an attempt to get some idea of the original size of the conch.

PLATE XXVIII

Fig. 1. *Actinoceras tenuifilum centrale* Var. nov. A vertical section through the center of the siphuncle. The apparent narrowing of the siphuncle at the top of the specimen is due to oblique weathering. The axial part of the siphuncle is occupied by an irregular tube filled by dark matrix; this is exposed by weathering at the top of the specimen and is glimpsed through the calcareous deposit in the lower part of the specimen. There also are traces of the tubuli which radiate from this axial part toward the annular segments of the siphuncle. Figure 4, on Plate 32 is a cross-section of the same specimen. From the Black River limestone at Watertown, New York. Received from Dr. Rudolf Ruedemann of the New York State Museum of Natural History.

Fig. 2. *Actinoceras tenuifilum* (Hall). A vertical section through the center of the siphuncle, tha latter narrowing toward the top. In the upper part of the specimen the axial part of the specimen was still comparatively open before



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the infiltration of the dark matrix. Toward the base of the specimen this tubular part is very much contracted. Traces of the tubuli radiating from the axial part also are present. Figure 1 on Plate 32 is a cross-section of the same specimen. From the Black River limestone at Watertown, New York. Received from Dr. Rudolf Ruedemann of the New York State Museum of Natural History.

Fig. 3. *Actinoceras tenuifilum ursinum* Var. nov. A vertical section exposing the siphuncle but not passing through the axial part of the latter. The cross-sections of this axial part, at the top and bottom of the specimen, show that it is dark in color like the matrix but very irregular in outline. Traces of the tubuli which radiate from the central axis are seen most distinctly where they approach the annular segments of the siphuncle, but a few cross-sections of these tubuli are visible near the axial parts of the siphuncle. Figure 6 on Plate 32 is a cross-section of this specimen. The same specimen as Figure 5 on Plate XIII of Holtedahl's paper "On the Paleozoic Series of Bear Island," 1919. From the *Tetradium* limestone of the Heclahook system on Bear Island, regarded as of Black River age. In the Palaeontologisk Museum at Kristiania, Norway.

Fig. 4. *Actinoceras* cf. *tenuifilum centrale*. A vertical section passing through the siphuncle. The latter apparently narrows toward the top. Figure 5 on Plate 32 is a cross-section of this specimen. From dolomitic strata of Black River age on either Boothia Felix or King William Land. In the Palaeontologisk Museum, at Kristiania, Norway; collected by Lieut. Godfred Hansen in 1903–04.

PLATE XXIX

Fig. 1. *Actinoceras amundseni* Sp. nov. *A*, ventral side of phragmacone, showing angular hyponomic sinus. *B*, opposite side of the same specimen, showing the siphuncle; the outline of the segments of the siphuncle are presented best by the lower part of the specimen. Figure 3 on Plate XXXII is an attempt at a restoration of its cross-section. From dolomitic strata of Black River age either on Boothia Felix or King William Land. In the Palaeontologisk Museum, Kristiania, Norway. Collected by Lieut. Godfred Hansen in 1903–04.

Fig. 2. *Actinoceras* sp. A natural vertical section of the phragmacone, showing the ventral location of the siphuncle and its relatively large size. From dolomitic strata of Black River age on either Boothia Felix or King William Land. In the Palaeontologisk Museum, Kristiania, Norway. Collected by Lieut. Godfred Hansen, in 1903–04.

1A

1B

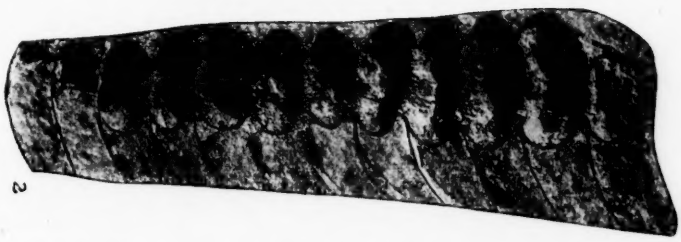

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PLATE XXX

Fig. 1. *Leurorthoceras hanseni* Gen. et Sp. nov. *A*, ventral side; *B*, dorsal side; the lateral side is shown by Figure 1 on Plate 31, with the ventral side facing toward the right. Figure 8 on Plate 32 is a cross-section of this specimen, showing the flattening of the ventral side. Either from Boothia Felix or from King William Land; in dolomitic strata regarded as of Black River age. In the Palaeontologisk Museum, Kristiania; collected by Lieut. Godfred Hansen in 1903–04.

Fig. 2. *Actinoceras* sp. *A*, ventral side of phragmacone; *B*, an oblique lateral view, showing most of the ventral side, and exhibiting the transverse striae along the ventro-lateral angle of the conch. Figure 7 on Plate 32 presents the transverse outline of this specimen near its top, but the ventral outline of the siphuncle is not known definitely. Either from Boothia Felix or from King William Land; in dolomitic strata regarded as of Black River age. In the Palaeontologisk Museum, Kristiania; collected by Lieut. Godfred Hansen, in 1903–04.

1A

1B

2A

2B

PLATE XXXI

Fig. 1. *Leurorthoceras hanseni* Gen. et Sp. nov. Lateral view of specimen figured on Plate 30 (fig. 1), with the ventral side facing toward the right.

Fig. 2. *Cyclendoceras* or *Dawsonoceras*. Apparently a part of a living chamber, with the median line of the ventral side about 10 mm. from the right margin of the figure. Either from Boothia Felix or from King William Land; from dolomitic strata regarded as of Ordovician age, but which may turn out to be Niagaran. In Holtedahl's paper "On Some Ordovician Fossils from Boothia Felix and King William Land," Figure 1 on Plate IV presents another species collected during the same expedition and undoubtedly from the same locality; in this specimen the sutures of the septa occupy the grooves between the annulations.

Fig. 3. *Cyclendoceras annulatum* (Hall). All but the extreme top of the type described and figured by Hall (Pal. New York, 1, 1847, pl. 44, figs. 1a, 1b). The ventral side is on the right of the figure. From Watertown, New York; in the Trenton limestone. No. 811 in the American Museum of Natural History in New York City.

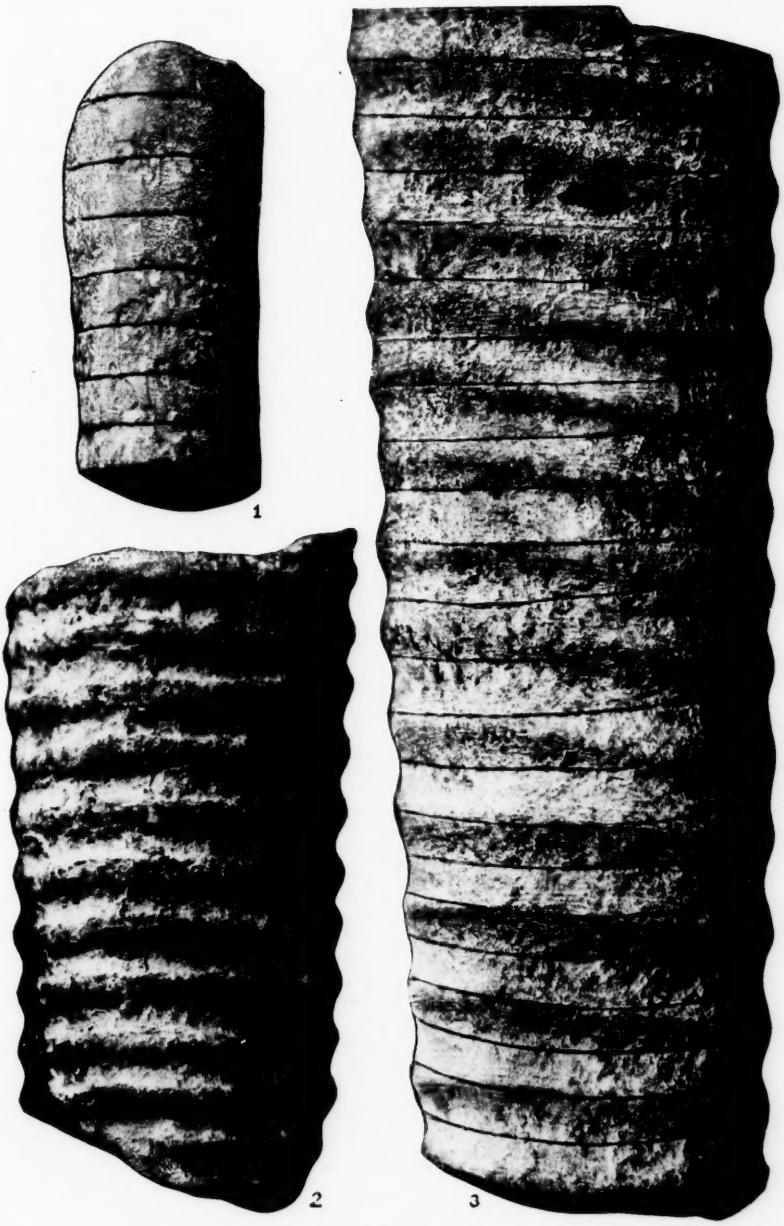

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PLATE XXXII

Fig. 1. *Actinoceras tenuifilum* (Hall). Cross-section of specimen, Figure 2 on Plate 28, from Watertown, New York.

Fig. 2. *Actinoceras* sp. Cross-section of specimen, Figure 7 on Plate 27, from either Boothia Felix or King William Land.

Fig. 3. *Actinoceras amundseni* Sp. nov. Cross-section of specimen, Figure 1, on Plate 29, from either Boothia Felix or King William Land.

Fig. 4. *Actinoceras tenuifilum centrale* Var. nov. Cross-section of specimen, Figure 1 on Plate 28, from Watertown, New York.

Fig. 5. *Actinoceras* cf. *tenuifilum centrale* var. Cross-section of specimen, Figure 4 on Plate 28, from either Boothia Felix or King William Land.

Fig. 6. *Actinoceras tenuifilum ursinum* Var. nov. Cross-section of specimen, Figure 3 on Plate 28, from Bear Island.

Fig. 7. *Actinoceras* sp. Cross-section of specimen, Figure 2 on Plate 30, from either Boothia Felix or from King William Land.

Fig. 8. *Leurorthoceras hanseni* Gen. et sp. nov. Cross-section of specimen, Figure 1 on Plate 30 and Figure 1 on Plate 31, from either Boothia Felix or from King William Land.

In all of these figures the missing parts are indicated by broken lines. Both the maximum and minimum dimenions of the siphuncle at the annulations and at the intermediate grooves are indicated.

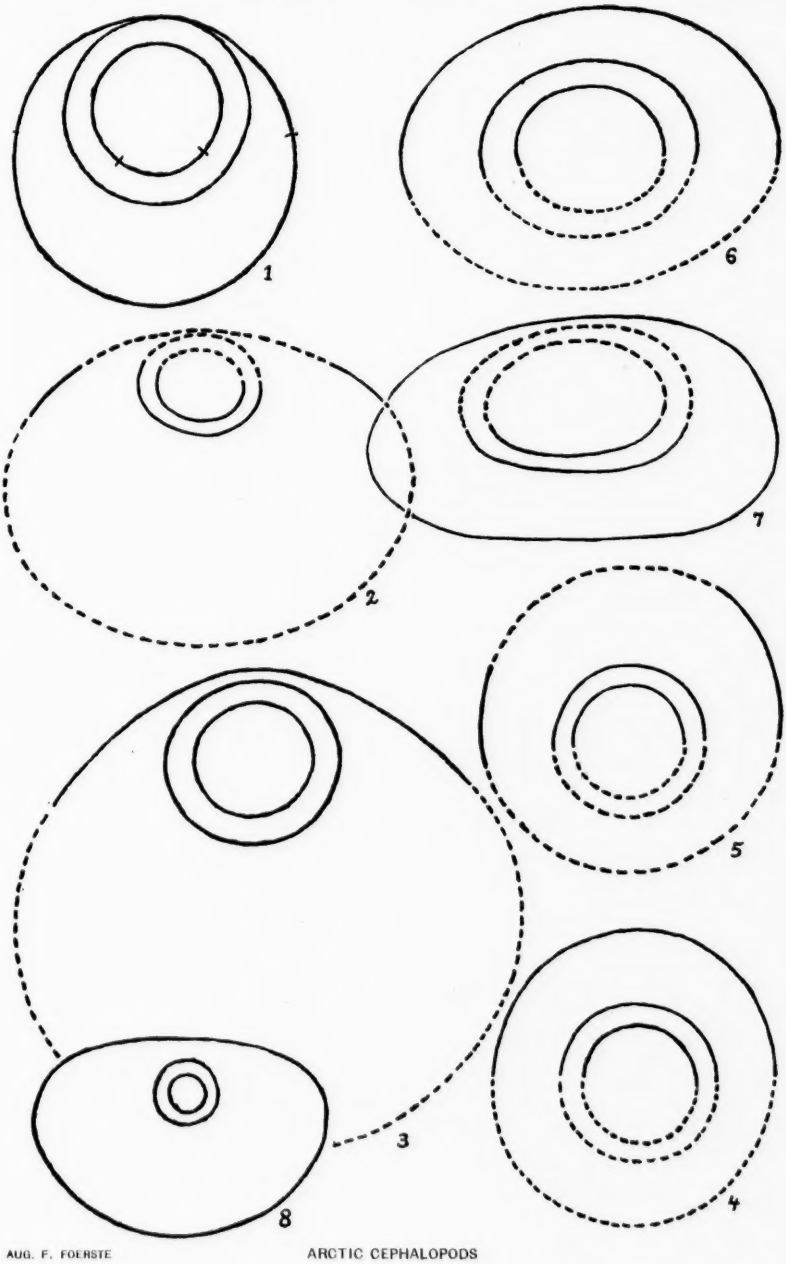

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PLATE XXXIII

Fig. 1. *Clarkoceras holtedahli* Sp. nov. Cross-section of specimen, Figure 2 on Plate 27, from Bache peninsula.

Fig. 2. *Eremoceras syphax* (Billings). Cross-section of specimen, Figure 8 on this plate, from Point Levis, Quebec.

Fig. 3. *Ellesmeroceras scheii* Gen. et Sp. nov. Cross-section of specimen, Figure 3 on Plate 27, from Bache peninsula.

Fig. 4. *Protocycloceras whitfieldi* Ruedemann. Vertical section of a specimen from Fort Cassin, Vermont.

Fig. 5. *Protocycloceras* cf. *lamarcki* (Billings). *A*, cross-section; *B*, vertical section; both sections based on specimen, Figure 5 on Plate 27, from Bear Island, but restored in part.

Fig. 6. *Deltoceras* (?) sp. *A*, chiefly a longitudinal section through the center of the siphuncle, parallel to the dorso-ventral diameter. *B*, an attempted restoration, based on the preceding. *C*, cross-section, showing the siphuncle. Same specimen as Figure 6 on Plate 27. From Bear Island.

Fig. 7. *Protocycloceras lamarcki* (Billings). *A*, specimen No. 550a of the type series, showing sutures of the septa. *B*, specimen No. 550b of the type series, showing the upper surface of a septum, with part of margin of siphuncle distorted by crushing. *C*, specimen No. 550c of the type series, showing sutures of the septa only near the base of the specimen. *D*, vertical section through the composite specimen 508 and 508a, showing the siphuncle. *A*, *B*, *C*, from Huntingdon county, Quebec. *D*, from Romaine on the Gulf of St. Lawrence. Of Canadian age. All specimens in the Victoria Memorial Museum, at Ottawa, Canada.

Fig. 8. *Eremoceras syphax* (Billings). *A*, ventral view, showing the large siphuncle. *B*, lateral view, with siphuncle on left. *C*, dorsal view, with pseudo-siphuncle made by tool-marks of the original cleaner of the specimen, formerly misinterpreted as the siphuncle. From Point Levis, Quebec, in strata of Canadian age. Type, numbered 819 in the Victoria Memorial Museum, at Ottawa, Canada.

Fig. 9. *Eurystomites* (?) *boreale* (Foord). *A*, lateral view of type specimen. *B*, incorrect cross-section, secured from cast of type at point *B* in Figure 9A. *C*, cross-section prepared from the original specimen, probably along the crack crossing the center of the type diagonally, as in Figure 9A; part of a figure drawn by Dr. F. A. Bather from the original specimen. From the Wellington Channel, in Arctic America, collected by Captain Inglefield. No. 96955 in the British Museum of Natural History, in London.

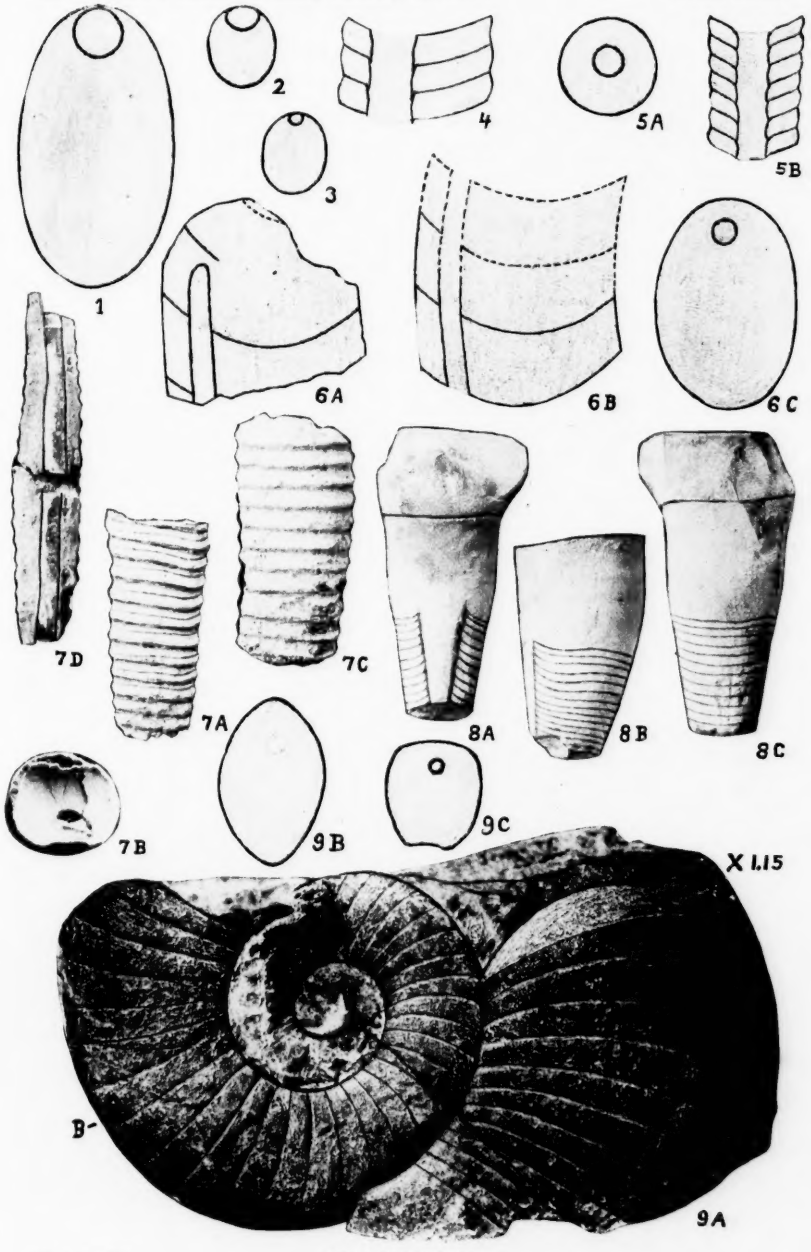
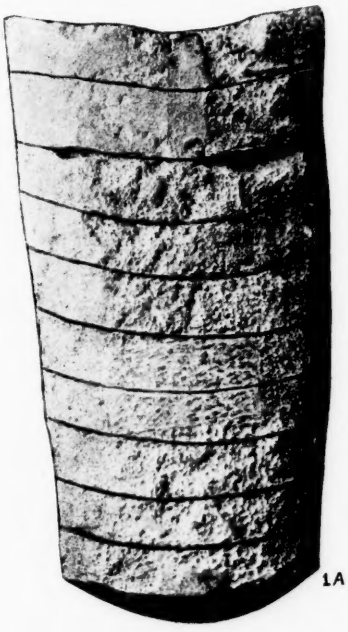

1
2
3
4
5A
5B
6A
6B
6C
7A
7B
7C
7D
8A
8B
8C
9A
9B
9C
X 1.15

PLATE XXXIV

Fig. 1. *Leurorthoceras chidleyense* Sp. nov. *A*, ventral side. *B*, lateral side. *C*, cross-sections at top and bottom of specimen, showing location of siphuncle at bottom. *D*, vertical section along dorso-ventral plane, showing siphuncle. From loose blocks of Black River limestone, found at Port Burwell, 20 miles west of Cape Chidley at the northern end of Labrador. No. 7923, Geol. Surv., Canada.

Fig. 2. *Leurorthoceras hanseni* Gen. et Sp. nov. Vertical section along dorso-ventral plane of same specimen as fig. 1 on pl. 30. The specimen was cut diagonally sufficiently to cause the siphuncle to appear narrower toward the top, though in reality it enlarges slightly in that direction. From the Black River limestone either on Boothia Felix or on King William Land.

Fig. 3. *Orthoceras* sp. *A*, dorso-lateral view, with ventral side on right, not showing the maximum slant of the sutures of the septa. *B*, cross-section, showing the slight flattening of the ventral side and the location of the siphuncle. From the Valley south of Borgen in Goose Fjord in southwestern Ellesmereland. From strata comparable with the Keyser member of the Helderbergian. In the Palaeontologisk Museum, Kristiania: collected by Per Schei in 1902.

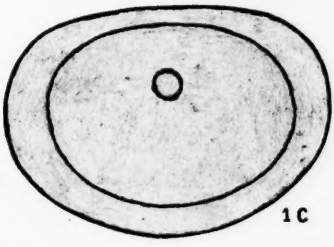


1A

1B

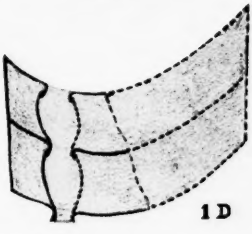
2

3B



1C

3A



1D

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PLATE XXXV

Fig. 1. *Kionoceras trentonense* Sp. nov. Lateral view, magnified 27/10. The alternation in size of the vertical riblets is shown best by the left half of the figure. From the original specimen represented by fig. 2 b, c, on pl. 56 of Pal. New York, 1, 1847. From the middle Trenton at Middleville, New York.

Fig. 2. *Kionoceras* sp. Lateral view, magnified 27/10. From the original specimen represented by fig. 3 on pl. 56 of Pal. New York, 1, 1847. From the lower shaly strata of the Trenton at Middleville, New York.

Fig. 3. *Actinoceras parksi* Sp. nov. View of a natural exposure of the interior of the siphuncle, showing on the left a polished vertical section exposing the septa, the long septal necks, and the relatively short connecting rings. From the Lower Rapids on the Shamattawa River, in northern Manitoba, west of Hudson Bay, in limestone of Ordovician age. No. 308 S, in the Royal Ontario Museum of Paleontology at Toronto.

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REVOLUTION VS. EVOLUTION: THE PALEONTOLOGIST RENDERS HIS VERDICT

KIRTLEY F. MATHER

I

Senators and bolsheviki, capitalists and members of the I. W. W., preachers and brick-layers, all, with few exceptions, are sincerely honest in their desire to improve the conditions, domestic, national and international, which determine the life and happiness of the individuals with whom they are acquainted. Most people would really be quite pleased, provided it did not entail too much labor or self-sacrifice on their own part, if the organization of society could be made more efficient and less wasteful, more subservient to the good of all and less profitable to the chosen few. We are still thrilled by the visions of the prophets of old and the propagandists of today with their dreams of a "new day" and a "new world." But just about there, our unity of mind and action ceases. Few among the real thinkers of any class are certain as to what these better conditions, which shall usher in the "dawn of the new day," shall be. And among these few, scarcely any two are agreed between themselves in regard to other than general and hazy ideas. More deplorable still, there are even more sharply defined differences of opinion among forward-looking men as to the method by which the reforms which they desire may be accomplished.

At bottom, it is really this difference of opinion as to method that distinguishes the Socialist with the Red Flag from the Republican with the Stars and Stripes, or the priest with his ritual from the evangelist with his sawdust trail. The distant goals which each envisions, although by no means coincident, at least have the merit of location in the same quarter of the universe; but the roads which are suggested as proper avenues

of approach to those comparatively adjacent goals are not even approximately parallel. The aims are similar, but the routes are various.

In general, would-be reformers—and that of course includes all adolescent or adult humans of sound or unsound mind—fall readily and naturally into two classes: those who believe in revolution, and those who believe in evolution. Each of these classes may be further divided into two sub-classes, dependent upon the reformer's notion of the forces which must be relied upon to accomplish successfully the desired result; reliance may be placed on the one hand upon human and natural forces, on the other upon suprahuman and supernatural.

Among those who believe in revolution, there are in the one group our inconoclastic brethren who have faith in the ability of the proletariat not only to overthrow the bourgeoisie but to perfect a new and beneficent organization of human affairs, which shall rise phoenix-like from the red flames of the blazing ruin of things-as-they-are. And on the other hand, in the same broad class of believers in revolution, there are those religious zealots who confidently await a day of destruction and judgment, when suprahuman forces shall be loosed in supernatural ways, and in the twinkling of an eye our present failure of a world shall be swept aside to make way for "the new heaven and the new earth."

In the ranks of the evolutionists, a similar cleavage is apparent. Some believe that the forces long operative, and even now operating, within the world are competent eventually to win mankind through to the high goal which seems to be set for him; that the Administrator of the Universe—to use Dr. T. C. Chamberlin's apt phrase—is powerful enough to make right forever triumphant without resorting to catastrophic destruction of the majority of his subjects. Others, impressed with the might of the quiet but constant forces of evolution and convinced of the futility of revolutionary expedients, fail to find the hope of better things in the present trend of affairs; rampant greed and unalloyed selfishness, eternal competition and bitter struggle, ever recurring tragedy, these seem to be the constant

companions of the evolutionary process from which the hit-or-miss method of Nature may never permit mankind to escape. For the disciples of evolution, who are thus led to believe in the impotency of natural laws and human worth, the future must indeed be black with despair.

Then, which shall it be? Evolution or revolution? Human ability and natural processes or suprahuman forces and supernatural power? Obviously, the question is far from being merely academic. One's whole philosophy of life, one's allegiance to the myriad welfare organizations of the land, one's alignment on the foremost political and social questions of the day, all these and more depend upon the answer. Nor is it a question which can be long postponed. So insistent has the clamor of the revolutionists become, that it penetrates even to the sequestered laboratory of the paleontologist and bids him rise from his study of fossil shell and petrified bone to give ear to the babel of twentieth century voices. And not unwillingly does he join the debate; for when it comes to a question of evolution who is there better fitted to make response than he who has visualized the stream of life which pulsed along the channels he has traced from those far-off Cambrian days until now?

Consider the lilies of the field and the birds of the air, the fishes of the sea and the creatures of the land. Retrace with the student of ancient life the long road that leads to man; watch the "phantoms behind us" marching step by step along that road. Search out the milestones of the past that mark the successful accomplishment of the great forward movements in life. For these creatures of the vanished ages, who have left the story of their lives recorded in the rocks of the earth's crust, are our kinfolk. Their problems are ours; our problems are but theirs. They have blazed the trail for us. The route to success and progress and "better things," which they found, is still open. The paths to failure, which they trod, are today as fair to look upon and as fatal to pursue as they have ever been.

II

Had you asked a paleontologist of two or three generations ago these questions which we are now propounding, the chances are he would have replied unhesitatingly that life had progressed in the past by virtue of a succession of violent and tragic revolutions. For this was the belief and teaching of Cuvier, Lord of France, and one of the greatest of the founders of the science of Paleontology. Embedded in the gypsum quarried from the hill of Montmartre, now included within the limits of the city of Paris, Cuvier had found remarkably well preserved fossil bones of animals which he correctly inferred had been living in that region at the time the rock strata in which they were entombed had been accumulated. His knowledge of living creatures from all parts of the world was unusually extensive, and he clearly saw that these relics of the past represented animals quite unlike any known existing ones. They must be members of vanished races, swept out of existence in the prime of life by some overwhelming catastrophe such as the inundation of the sea over a subsiding continent, but whose remains had been fortunately preserved and were now displayed in Nature's vast museum. Perhaps the very floods of sea water from which the gypsum had been precipitated had also drowned the hapless inhabitants of the land, whose bones were buried on the sea floor.

Thus arose the doctrine of "catastrophism," a doctrine which was subsequently expanded until it enthroned the principle of revolution as the prime factor in the forward march of life. In the minds of Cuvier's followers, during the earlier half of the nineteenth century, it was the general belief that the cataclysms were world-wide, and that the slaughter of the older assemblage of animals and plants was followed by the special creation of a new and more improved group of creatures to inhabit the vacant spheres of activity. D'Orbigny, for example, taught that "twenty-seven times in succession, distinct creations have come to repeople the whole earth with its plants and animals after each of the geological disturbances which destroyed everything in living nature."

Or, if the idea of numerous "distinct creations" is somewhat repugnant because it leaves open the way for the flippant suggestion that the Creator was not at first an expert artisan but required a lot of practice before he became sufficiently adept to perform his functions properly on a certain Saturday in the year 4004 B.C., the theory of catastrophism may be slightly amended. Let it be supposed that the devastating cataclysm was not quite world-wide, but that individuals here and there escaped to become the progenitors of the new assemblage of living creatures. This was apparently about what Cuvier really had in mind. In times of excessively arid climate there would somewhere be an oasis where a few favored individuals would escape the parching drought. When a glacial episode threatened to freeze the inhabitants of land and sea and spread a mantle of Artic snow and ice over all the face of the earth, the climatic pendulum would be reversed just in time to save a dwindling minority to serve as seed for repopulating the ice-freed lands. Volcanic fires and earthquake shocks ordinarily would not completely devastate all habitated places of the earth's crust at any one time; somewhere a few individuals would escape to provide descendants capable of returning to the wasted lands when the cataclysm had ceased. Tyre and Sidon went on their wicked way unscathed when fire from heaven rained down upon Sodom and Gomorrha, you will recall. Or perchance, safety from inundating sea or deluge might be found upon a high plateau or mountain top, such for example as Mount Ararat.

Thus by comparatively easy stages we might shift from the camp of Cuvier and d'Orbigny to another school of old masters in the science of Paleontology, among whom Sir Charles Lyell was foremost. Long before the time of Darwin, this group of scientists had come to believe in evolution of one sort or another and pinned their faith to the doctrine of "continuity." They noticed that there were certain "long-lived" species of animals and plants, whose remains were found unmodified in formation after formation regardless of the catastrophes which might have occurred in the intervals between their deposition. On the coast of Wales at the present time, for instance, certain

brachiopod shells which weather out of rocks dating back to the very oldest of fossiliferous strata are scarcely distinguishable from the shells of living brachiopods washed ashore by the waves which are daily exhuming the relics of antiquity from the cliffs against which they dash into spray.

Again, these believers in the continuity of life, regardless of local disturbances, adversities and cataclysms, called attention to the fact that the fossil remains of successive groups of plants or animals were as a rule indicative of creatures only slightly modified from those which had preceded them. Abrupt and sweeping changes in the assemblage of living beings were apparent whenever there were gaps in the record of life, but when the missing chapters were supplied by more extensive study the vital stream was shown to have been flowing on its way unbroken. Proof was not lacking that the presence of an altogether different assemblage of fossils in two successive series of rocks was due to the migration into that locality of creatures who had been slowly developing elsewhere. The pulse of life might beat a little irregularly now and then, but never had it been entirely suspended.

Gradually this notion of continuity of life, regardless of seeming interruptions in the record, gained sway, and at the present time there are no paleontologists who entertain any other idea of organic development. But still our question is unanswered. Granting the unbroken flow of the stream of life, what part in the progress of that stream has been played by the rapids and cataracts? Have they been essential to its onward flow, or are they only spectacular displays, actually of less importance than the quiet reaches where the deeper waters move?

III

The close of the Paleozoic Era—that long interval of ancient time during which invertebrates and fishes, with later the addition of amphibians and reptiles, were the only animals upon the earth—was marked by a series of adverse episodes so disturbing in their influence upon plants and animals that it brought about what is commonly called a "revolution" in the organic

world. Episode number one in the thrilling serial was a crustal movement which crumpled the outer layers of the earth into a long line of mountain ranges stretching across what is now Belgium, Northern France and Southern England. These, the "Paleozoic Alps" of Europe, have long since been worn down and washed into the sea, but the roots of the quondam cordillera still remain. This crustal crumpling was accompanied by a general upward movement of all the continents and a deepening of the ocean basins so that shallow seas which had hitherto spread out over a large proportion of the continental platforms retreated oceanward and left dry land or broad swamps where great bays and estuaries had been. It so happens that the overwhelming majority of marine organisms are adapted to life in the shallow seas alone. The greater part of the deep sea is nearly or quite devoid of life; only in the upper hundred fathoms and on the ocean floor are living creatures found. More than 95 per cent of all the inhabitants of the sea are confined to the shallow coastal waters between the strand and the hundred-fathom line. Previous to this crustal disturbance, the area of this particular zone had been very large and life had expanded and multiplied therein. Now, its area was reduced to a small fraction of its former extent, and the severity of the struggle for existence that must have taken place within this dwindling zone can well be imagined.

Then followed episode two. Gradually the climate of the world changed from its former agreeable warmth to Arctic cold. Great ice sheets, far more extensive than those of the much later and better known epoch to which the name "The Great Ice Age" is frequently applied, formed upon the lands and spread in all directions. In India and in Bolivia these glaciers reached even within the tropics, while in South Africa and Australia they were only slightly less extensive. The life of land and sea, alike, was diastrously affected by these adverse climatic conditions, and the end of the Paleozoic Era marks also the termination of scores of genera and families and even of many orders of animals and plants.

Episode number three was somewhat similar to that which had opened this chapter of earth history. Its chief event was the building of the Appalachian Mountains, which in their youth were mighty ranges not unlike the Rockies of British Columbia. The areas of hospitably shallow seas were still further reduced, and vast sandy plains stretched monotonously across the states of Texas, Oklahoma and New Mexico. Deserts, equalling the Sahara in magnitude and aridity, existed in parts of Europe and North America where today are fertile farms and majestic forests. The tribulations heaped upon the creatures of the land became even more numerous than before, as the humid areas of temperate climate were still further diminished in extent and number. The physiographic and climatic changes wrought during these three episodes in earth history could not fail to leave their indelible imprint upon the entire population of the globe, composed as it has always been of individuals quick to respond to modifications in their geographic environment.

With the crumpling of the Appalachians, the mighty forces pent within the body of the earth seem to have spent their energy. Equilibrium of the opposing stresses was once more attained. The close of the Paleozoic Era was followed by another long era of comparative stability of the earth's crust. Gradually the normal temperate climate of the globe was restored; once more, broad shallow seas crept over the lower portions of the continental platforms; again, the regions of land and sea most hospitable to life expanded until they covered a large proportion of the planet; a long era of prosperity for the earth's inhabitants was ushered in. This, the Mesozoic Era, the time of medieval life, is referred to as the Age of Reptiles, because during it the animals of this class aspired to the rulership of every domain of life, the land, the sea and the air.

What were the effects of these revolutionary episodes upon the creatures subjected to them? Were they for good or for evil? Space forbids a full discussion of the problem; we may concentrate our attention upon a single class of animals and take their experiences as typical of all. And I choose from among the many available illustrations that afforded by these

self-same reptiles whose numbers were so great during the age which followed, for to me their story is fraught with the greatest interest.

D'Orbigny taught that the reptiles were created immediately following the world-wide cataclysm, into which the three episodes enumerated above were exaggerated, as a part of the process of re-peopling a world from which all life had been annihilated. But the researches of Williston and others have revealed the fact that the reptiles had been in existence long before these staggering events, had indeed progressed far along their varied and spectacular career before the close of Paleozoic time. Already they had deployed into several distinct orders; already more than one strain had risen to the climax of its career, tasted the fruits of success in its chosen line, and passed away, blotted out of existence in the never-ceasing competition of rival races, or failing utterly to withstand new and adverse conditions in their environment.

Take for example the curious "fin-backed lizards," known to science as Pelycosaurs. From each vertebra of their spinal columns a long bony spine grew vertically upward, and, the whole series sheathed in leathery integument, formed a "fin" along the middle of their backs. Successive genera are known with increasingly high fins until the climax of this reptilian strain was achieved in a creature whose fin was twice as high as his back even when his body was lifted as far from the ground as was possible for his stubby legs to elevate it. His fin spines were more than two feet long and each was decorated by short spicules of bone growing horizontally at right angles to the long bony column. Just what purpose was served by these bizarre appendages is not known; whether for decoration, defense or other practical use, it matters not in the present discussion. The important fact is that this entire reptilian race was swept out of existence at the close of the Paleozoic Era and left, so far as now known, no descendants to make their contribution to the Age of Reptiles.

Again, there lived at this time one group, the Mesosaurs, who had become entirely adapted to life in the fresh waters of rivers

and lakes. They are among the first of many creatures who forsook the land, modified their legs into swimming apparatus of one form or another, mimicked the fishes in the shape of their bodies, and returned to the water which their remote ancestors had long before deserted to invade the new terrestrial domain. Interestingly enough, these fresh-water reptiles are known to have lived during the closing epochs of the Paleozoic Era only in South America and South Africa; how they travelled from the one continent to the other, they could not exist in the salt water of the sea, is one of the unsolved problems of the paleontologist. They, too, had their day and ceased to be, and their whole life history was closed before the Age of Reptiles began.

But several of the reptilian strains were more successful or more fortunate; they persisted, to become not only the progenitors of the varied saurian masters of the Mesozoic Era but of the higher class of birds and still higher mammals as well. Clumsy, crawling creatures they were, with much bone and little brain in front of their squat shoulders. Heavy in body, short in leg, many of them could little more than drag their trunks over the sand or through the mud. For some of them the vast arid tracts seemed purposely designed, and there they multiplied in number, deployed into several different evolutionary strains and slowly, conservatively perfected that complete adaptation to the dry land which was necessary to the further progress of life. Truly reptilian in habits, the cold blood which coursed sluggishly through their veins was not shocked by the icy drafts of the glacial climates. The disastrous episodes which closed the Paleozoic Era left them unscathed; the rush of the stream of life swept them forward to the high destiny which they realized in the Age of Reptiles.

But their success was not achieved as a result of the revolutionary events which mark the transition between those two eras. They had already won for themselves their leading parts in the drama of life. Long ages of quiet unassuming preparation had preceded those spectacular moments. The slow and steady progress which they were making seems simply to have been accelerated by the very adversities of that comparatively

short interval of upheaval. The revolution was a success only because of the preceding preparatory development which progressed so deliberately and inconspicuously that it entirely escaped the attention of the earlier students of ancient life, thrilled as they were by the apparantly abrupt and sweeping changes which the revolution wrought. Those "reforms" were merely the climacteric fruition of a lengthy period of preparatory evolution.

Examples without number, drawn from other classes of animal and of plant life at this same milestone in the progress of life, parallel this one. The same story recurs again and again as other milestones are passed. We may pause for but one other illustration.

The transition from the Mesozoic Era to the Cenozoic Era, the era of modern life, is marked by physiographic and climatic changes not unlike those which characterized the transition just sketched. Once more, the stresses slowly accumulating within the rigid body of the earth were piled one upon another until they could be no longer resisted; the pent-up energies must be released as before. But the chief scenes of the drama were staged in other places; the most conspicuous milestone is found where the American Cordillera rears its cloud-swept peaks from Alaska to Cape Horn. This mightiest of all but one of the modern mountain systems dates its birth from the close of the Age of Reptiles. The travail which brought it into existence was marked by violent volcanic outbursts on a gigantic scale; Vesuvius, Stromboli, Krakatoa, Pelee and Mauna Loa, all crowded into a single county and set in simultaneous eruption would perhaps give some idea of the events which constitute episode one of this second serial. Again, there was a general elevation of the continental platforms and a withdrawal of the shallow seas to the newly deepened ocean basins. Again, there were far-reaching climatic changes; even another glacial episode, if, as seems probable, the glacial deposits recently discovered in Colorado and British Columbia date from this time. Again, there was a second mountain-making crumpling of the earth's crust, this time concentrated in the same cordillera

which had come into being as a result of episode one and therefore much more difficult of interpretation. All in all, the changes in the physical environment of the earth's inhabitants were nearly or quite as sweeping as those which resulted in the striking modifications of life as it passed from the Paleozoic to the Mesozoic types. And, as before, the living creatures responded to these changes so completely that another "revolution" is recorded in the older text-books. In a word, the host of reptiles which had dominated land and sea and sky were swept into oblivion and their places were promptly assumed by mammals, the most advanced of all creatures. As a consequence, the Cenozoic Era is known as the Age of Mammals.

Again, let us enquire more particularly into the history of the group of animals which seem to have profited most by this "revolution." To state it briefly, the story of the mammals at this time is almost an exact parallel to that of the reptiles at the close of the Paleozoic Era. Instead of having been created subsequent to the devastating catastrophe which was believed to have left an uninhabited world for them to people, we now know that they had long been in existence. The first relics of mammalian life date far back in the Age of Reptiles. Before its close there were countless hordes of small warm-blooded creatures, competing, in spite of their insignificant size and by virtue of their superior brain power, with the gigantic and powerful but clumsy and unintelligent reptilian masters of the world. This very competition, carried on during at least three geologic periods, gave them strength and cunning not only to outwit their opponents but also to adapt themselves even to such adverse environmental conditions as surrounded them during the geographic revolution inaugurated by the first birth-pains of the American Cordillera. Far more ready to profit by its changes, because of their mobility, their warmth-preserving pelts and their intelligence in securing new food supplies, than were the reptiles, they succeeded where their competitors failed. Coincident with the return of the balanced conditions which lead to long periods of comparative stability of the earth's crust, the mammals promptly acceded to the

many thrones left vacant by the reptiles, unable to withstand the adversities of climatic and physiographic change coupled with the ever-increasing ability of their mammalian foes, and soon dominated land and sea. Soon thereafter they even aspired to the dominion of the air, but in that sphere of activity they have thus far failed to rival the birds.

The conclusion seems unescapable that again the revolutionary achievement was merely the climax of a long slow upward climb. Had not the preparation of the mammals been complete they could scarcely have seized so successfully upon the opportunities which opened before them at this time. The conclusion is further fortified when we note that the immediate ancestors of mammals, the theriodont reptiles, had been in existence before the close of the Paleozoic Era, but, though they foreshadowed the mammals in many important particulars of body structure, they apparently made no marked response to the environmental changes occurring at the close of that era. The long preparatory period had but begun for the mammalian strains; not yet had they attained the abilities sufficient to profit by those changes; that "revolution" gained them little or nothing, simply because they were not ready to take advantage of it. The inauguration of the mammals as the lords of the earth must wait, regardless of "revolutions," until the offspring of those theriodents had by the long slow processes of evolution completed the training prerequisite to that proud position.

This seems to be the law of life. Revolutions are of little avail unless preceded by long and generally agonizing periods of preparation. Slowly progressive evolution may lead to a spectacular climax of fruition during a moment of organic upheaval, but the attainment is the result of the preparatory development, not of the revolutionary forces. Time and again, upon the long road so painfully traversed during the geologic eras, important milestones have been passed, great upward steps have been achieved, unaccompanied by anything remotely resembling a "revolution;" but never, so far as I am aware, has any group of animals or plants gained advantages at times of

crisis without long antecedent training which paved the way to their success. In the stream of life, the cataracts and rapids are but spectacular manifestations of the fundamental forces which gain their ends effectively in the slowly moving reaches where the quiet waters irresistibly flow.

IV

There is a wide-spread opinion "that the idea of the continuous development of the life of man on the earth was something foreign to the mind of Jesus; the idea of catastrophe, it is contended, was ever present to him. On the wreck of the world his Messianic kingdom was to be established." It is the view held, consciously or unconsciously, by the great majority of churchmen throughout all Christendom. Opposed to it is the concept, rapidly gaining adherents in the present generation, that the Man of Galilee put no trust in destructive revolutions, but had a firm and sure faith in the evolutionary forces quietly operating within the lives of men. The issue is sharply defined. Did the Great Teacher instruct his hearers in the dogma of revolution or in the doctrine of evolution, in the necessity of world-destroying upheavals or in the efficacy of quietly progressive growth, in the purification of the world by fire and sword or in the attainment of man's high destiny along the less spectacular roadway of spiritual and mental development?

Consider for a moment the remarkable assemblage of the "Parables of the Kingdom" in the thirteenth chapter of Matthew's gospel. Here are intermingled the evolutionary parables of The Sower, The Mustard Seed, The Leaven, each with its unmistakable emphasis on growth, development, progress from within, and the revolutionary parables of The Tares and The Net with their references to the harvest time of reward and destruction, to the end of the world in catastrophe and upheaval. The Founder of Christianity was a master in the art of finding and clinging to the happy medium of carefully balanced judgment. Never was he guilty, as have been so many of his followers, of pushing a great truth to a ridiculous extreme. And upon this greatest of Christian themes he has carefully chosen

and maintained the middle ground. Progress, even to the attainment of the new heaven and the new earth, even to that glad day when all men shall be enrolled in the kingdom of heaven, is the result of growth and evolution; but the long summer of development bears fruit in the autumn of harvest; the era of quiet progress paves the way for a climax of fruition; long ages of slow preparation, so slow and inconspicuous as to appear negligible to the superficial observer, finally achieve results with startling suddenness. Lest his hearers spring to arms with a frenzied desire to sweep their fellowmen without delay into his new kingdom under penalty of death if they refuse to enter there, he calmly, dispassionately speaks of the seed-time and the leaven, the gradual growth of the tree and the long summer of increase. Lest they become impatient of delay, discouraged with the apparent paucity of achievement, he turns their attention to the harvest-time when the results of growth are tested and rewarded according to their merits, he speaks of the closing moments of an era when the pulse of life is accelerated and preparatory development attains fruition in new opportunities for further progress.

It is as though the humble Carpenter of Nazareth had with the student of life development surveyed the river of life and had seen it sweeping quietly, irresistably onward to plunge in a cloud of spray over the brink of a cataract, then to stagger for a moment before it regains its sense of direction and slips silently ahead into another long reach of steady movement. The lesson from the past is clear. The progress of life has been a result of evolution and of growth, quiet, unassuming, slow; but ever and again progress has been revolutionary in its nature, and by virtue of abundant preparation there has come a time of swift attainment, a climax of success. Revolutions in the past have been truly catastrophic for those organic strains whose preparation has been inadequate, but in the progress of life as a whole they have been merely minor incidents, a quickening of the pulse, an acceleration of the continuous process of evolution.

V

From the paleontologist's vantage point on the reviewing stand, the creatures of the earth appear in this twentieth century to be approaching another milestone in their progress. There are rapids and cataracts just ahead; once again, the stream of life is gathering its energies to leap forward with increasing velocity until it plunges swiftly over the brink of another falls. A crisis in life development, fully as critical as those which opened and closed the Age of Reptiles, is close at hand. Survival values once again have changed, but the same principles which selected certain groups of animals to weather those "revolutions" of the past will doubtless guide certain of the existing creatures through the dangers in the offing. The crisis recorded in the rocks of latest Paleozoic Age, was forced upon the land animals by changes in climate and environment; it was successfully passed by creatures who specialize in the adaptation of their bodies to cold and drought, and who escaped from the crowded confines of the sea to the almost uninhabited silences of the land. The "revolution" involved in the dethronement of the reptiles and the exaltation of the mammals at the close of the Mesozoic Era was likewise precipitated by external changes over which the mammals themselves had no control; it bettered the condition of creatures who specialized in the care of their young and the use of their brains. Each group which prospered had for some time displayed the very characteristics which proved efficacious in the time of stress; the "revolution" afforded the opportunity for the testing and the rewarding of the products of progressive evolution.

The crisis of tomorrow, already imminent, is likewise in its real essence the result of external conditions over which man has so far displayed no control. The world has lost its corners and shrunk into a neighborhood; but man is not to blame because ocean highways link its farthest islands, and mountain barriers fail to subdivide its lands. The resources of the earth are proving inadequate to support a large population of idle rich or idle poor, without an excessive load being placed upon the

workers; but it is not the fault of man that the stores of iron ore are limited, and the acres of tillable land are numbered. As in the past, so in the twentieth century, the impelling forces of progress are inherent in the environment; the response must be dependent upon virtues intrinsic in the creatures who are to be thus tested. Some will undoubtedly be found wanting; for them the penalty has always been either extinction or stagnation. Others—and in the past it has generally been a minority—will respond with habits that will prove to be their salvation; they, and they alone, will profit by the revolution.

To prophecy is always to incur the danger of post-mortem pillorying. But it requires no unusual acumen to see that this next milestone in the progress of life will be safely passed only by those who specialize in the art of coöperation, as opposed to selfishness, and in the practice of kindly thoughtfulness for others, regardless of their color, race or creed.

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